EERC

ENVIRONMENTAL ECONOMICS RESEARCH COMMITTEE

Theme: Industrial Pollution and Policy
EERC Working Paper Series: IPP-8

An Environmental Assessment of Oil and Gas Exploration

V B N S Madduri

University of Hyderabad, Hyderabad

MOEF IGIDR WORLD BANK

AN ENVIRONMENTAL ASSESSMENT

OF

OIL AND GAS EXPLORATION

Final Report

Submitted to the

Indira Gandhi Institute of Developmental Research

Mumbai

For

The World Bank Aided Project

Environmental Management Capacity Building Technical Assistance India

Dr. S. Madduri

University of Hyderabad

Hyderabad

And

Mr. E. Mohan Reddy

Oil and Natural Gas Corporation

New Delhi

January 2003

CONTENTS

Acknowledgement

We thank the World Bank and Indira Gandhi Institute of Developmental Research (IGIDR), Mumbai, for financing this study under their Environmental Management Capacity Building (EMCaB) Progamme. We are indebted to Prof. Jyothi K. Parikh, Senior Professor, IGIDR, and Chair Person, Environmental Economic Research Committee of the EMCaB Programme for providing the initiative and to Prof. Kirit Parikh, IGIDR for guiding us through out this. We would like to acknowledge the active support received from the team of ONGC officials – Mr. S.S.Lamba, General Manager, Safety and Environment, Mumbai, Mr. Rangarajan and A. Jayaraman of the Institute of Petroleum Safety and Environment Management, Goa, Mr. B. S. Kapale and J.S.Thakur from Safety and Environment Division at Mumbai, Mr. K. T. R. Rao and Mr. S. Jaswal from Rajahmundry Division of the ONGC, Mr. N. N. Taye from ONGC Office at Nazira in Assam and officials at all the Research Institutes of ONGC for faciliting the collection of necessary data. We are grateful to Mr. Ajaya Raghava of the Central Pollution control Board for providing the required data. We also thank the University of Hyderabad for their involvement and collaboration. We thank, Dr. P. Balachandra, Scientific Officer, Department of Management Studies, Indian Institute of Science, Bangalore for his valuable comments throughout the course of this project. We record our appreciation to Ms. M. Syamala, Ms. U. K. Mini and Ms. P. Praveena Sri of the University of Hyderabad for their research assistance and Dr. R. Murugesan for data analysis of the socio-economic survey. Dr. Lanin Babu and Sri. Venugopal Reddy from the Bangalore University and Sri. Kiran Rajasekharaih from IGIDR had has helped us in collecting the information from various sources and put them in proper format. Our sincere thanks to them. Mr. Pullela Ratna Prasad, the joint coordinator of Net PEM (Network for Preventive Environmental Management) is responsible for conducting the workshop at Nagpur, at their primises, and involving various experts around the country. The discussions were valuable and we thank him for his staff, profoundly, for their cooperation. Ms. Jyotsna M. S helped in computational and typing activity during the preparaton of this report. We thank her sincere efforts in completing the report with illustrations etc.

A study of this nature which involved collection of village level data would not have been possible without the willingness and cooperation of people from the seven villages viz., Kesanapalli, Karavaka, Ethakota, and Pasarlapudi (A.P), Konwarpur and Hatipati (Assam) and Jangira (Maharashtra) and the respective ONGC officials. We extend our thanks to all of them. We thank the EMCaB team consisting of Dr. Raghuram Tata and Mrs. Radha Ramamurthy for their timely help, which made it possible for us to finish this study effectively.

V. B. N. S. Madduri

E. Mohan Reddy

CHAPTER 1: INTRODUCTION

Background and Justification:

Humanity has always in need of a variety of energy resources for the development of civilization and making life more comfortable. Exploration of energy resources has played an important role in generating and sustaining individual development and economic growth. Increased importance is being given presently, to the exploration and development of conventional energy resources like oil and natural gas, locally referred to as refinery outputs. Petroleum generally, occurs in sedimentary deposits in a complex mixture of hydrocarbons, which exists under the ground, naturally in gaseous (natural gas), liquid (crude oil), and solid (asphalt or coal) state.

The society's dependence on oil and gas been increasing at an alarming rate. This increased utilization necessitated the exploration, development, production and transportation of hydrocarbons. The consequences of increased use of these hydrocarbons resulted in environmental degradation. [1] There are also other potential environmental hazards at the time of these operations including the danger of "blowout", which was the case in recent years. In India not much work has been done to study such environmental impacts.

With reference to natural gas extraction, there are other precautionary measures need to be in place. The natural gas is extracted with the same kind of technology used in petroleum extraction. In this case, gas must be kept under pressure once it reaches the surface. Otherwise, "blowout" can happen while drilling and nay ignition (spark) before capping the well may lead to ghastly fire. This will lead to irreversible environmental damage. Equally serious problem is the disposal of waste that is generated at the time of drilling (exploration and development). At the time of drilling a sizable amount of mud is collected (slurry) and discharged into the open areas. This mud waste contains hazardous substances (a hazardous substances is one that exhibits, corrosivity, reactivity or toxicity) such as nitrogen, oily waste, paint thinner, paper; card board, glass etc.; pipe dope (lead, Zinc, or copper based), propane, rig wash (sodium carbonate, sodium meta silicate); scarp plastics, varsol; lime, oxygen scavenger; soda ash; zinc carbonate, etc.

Flaring is an important safety procedure, especially at facilities that handle sour gas. The hydrogen sulfide (H_2S) in sour gas is toxic and heavier than air. In case of gas flaring, environmental damage is quite significant. This can happen to both on shore and off shore operations. If not flared, it could pose hazard to workers and neighbours. Flaring converts H_2S into less toxic sulfur dioxide (SO_2) which is dispensed in the plume of hot gases from the flare. This activity requires regulation of the industry. The objectives of the present project are to focus on all these issues and come up with various policy guidelines.

It is the duty of every Indian, including those working in the oil gas sector, to protect and at the same time pursue the goal of economic development. One way to achieve this is through sustainable development "*that meets the needs of the present generation without compromising the availability for future generations.*"

Objectives of the Study

The main objectives of this study are:

i) to assess the effluents and other substances discharged in the neighbourhood of the drilling site;

ii) a quantitative assessment of the type of drilling – depth, type of substances discharge in air, water, and soil;

iii) linkages of drilling activity with the environemental degradation;

iv) to identify regulatory mechanism and guidelines in India in relation to the similar regulations, in place in other countries, for the waste management,

v) to suggest policy guidelines for the reduction in environment damages.

Liberalization

With the liberalization of the Indian economy, more companies from the private sector are entering the field of exploration for Oil and Gas. About five years back, the Government of India has introduced the National Exploration Licensing Policy (NELP), a new system that encourages the private sector to form Joint Ventures and participate in the development of petroleum industry.

Historical Background

The oil and Gas industry is truly global, with operations conducted in every corner of the globe, from Alaska to Australia, from Peru to China, and in every habitat from Arctic to desert, tropical rainforests to temperate woodland, from mangrove to offshore. The global community will rely heavily on oil and gas supplies for the foreseeable future. World primary energy consumption in 1994 stood nearly at 8,000 million tonnes of oil equivalents; oil and gas represented 63 per cent of world energy supply, with coal providing 27 per cent, nuclear energy 7 per cent and hydroelectric 3

BOX-1: SOME FACTS ABOUT OIL

- The total world consumption of crude oil in 1996 was 71.7 million barrels per day (there are 42 US gallons in a barrel, or 159 litres). OPEC estimates that total world oil consumption could reach around 100 million barrels per day by the year 2020.
- In 1996 there were 1,047,200 million barrels of proven crude oil reserves, of which 76.6 per cent was in OPEC Member Countries.
- EIA estimates that, based on recent USGS estimates of the global oil resource base, worldwide oil production is likely to continue increasing for more than three decades.
- Oil spills account for only about five percent of the oil entering the oceans. The Coast Guard estimates that for United States waters sewage treatment plants discharge twice as much oil each year as tanker spills. During the last decade, more than one billion gallons of oil spilled worldwide.
- The amount of petroleum products ending up in the ocean is estimated at 0.25% of world oil production: about 6 million tons per year.
- Widespread manmade pollution of the sea that can be detected by current space borne systems is concentrated in the Middle East, particularly in the Persian Gulf and the Gulf of Oman.
- Oil supplies the US with 30% of its energy, 50% for the UK, 10% for Japan, 22% for India and 90% for Nigeria Natural gas supplies the US with 26% of its energy, 18% for the UK, 4% for India and 3% for Japan
- OPEC forecasts that oil demand will continue to grow strongly and oil will remain the world's single most important source of energy for the foreseeable future. OPEC forecasts that oil's share of the worldwide energy market will fall from almost 40 per cent in 1995 to less than 37 per cent in 2020. But oil will still be the world's single largest source of energy. The reduction in oil market share is largely due to the stronger growth enjoyed by other forms of energy, particularly gas. The amount of oil demanded worldwide is actually expected to rise, from around 70 million barrels per day in 1995 to about 100 million barrels per day in 2020.
- Within thirty years a billion more people will be living along the coasts than are alive today.

per cent. The challenge is to meet world energy demands, whilst minimizing adverse impact on the environment by conforming to current good practice. The exploration of oil and gas reserves has never been without some ecological side effects. Oil spills, damaged land, accidents and fires, and incidents of air and water pollution have been recorded at various times and places. In recent times the social impact of operations, especially in remote communities, has also attracted attention. Box: 1 reveals some bare facts about oils and gas related issues of environment and development concern. The oil and gas industry has worked for a long time to meet the challenge of providing environmental protection. Much has been achieved, but the industry recognizes that even more can be accomplished. For example, the United Nations Conference on Environment and Development (UNCED) that held in Rio de Janeiro during June 1992 ('The Earth Summit') focused world attention on the close links that exist between the environment and socio-economic development. The summit resulted in Rio Declaration and Agenda 21 – plan of action. The central message of Agenda 21 is the interdependence and cross-sector partnership, and the plan of action provided a new approach to the wide-ranging socio- economic and environmental challenges the world community is facing.

Exploration of Oil and Gas – The Indian Scenario

Exploration for hydrocarbons in India dates back to 1866, when Assam Oil Company initiated the exploration efforts in upper Assam. These conventional efforts coincided with the first ever exploration for hydrocarbons in Pennsylvania State in USA, where first oil well was drilled in Titusville. Assam Oil Company developed Digboi Oil Field in 1889. Subsequently this company extended its exploratory efforts to Barrack Valley in 1930 and a small oil field at Badarpur was developed. This company further carried out exploration for up thrust blocks in Naga Hills. The search for the hydrocarbons was confined to North Eastern part of the company, till the formation of National Oil Company ONGC in 1956. As a result of its massive countrywide efforts, it has been possible to lay down the foundations of petroleum sector in the country.

The decade of sixties marked the initial stage of exploration, which is characterized by building the conceptual framework technologies and structuring the exploration efforts. In this decade exploratory efforts were initiated in the concession areas of ONGC in Upper Assam. Many "large" and "medium –size" fields were discovered and interesting exploration leads were obtained to intensify future exploratory efforts. Reserve accretion from the discoveries grew at a fast phase.

The decade of seventies was marked by exploration in offshore basins. In this decade “giants” like Bombay High Basin and a number of medium to large offshore fields were discovered. In the onshore areas, the number of large discoveries became relatively scarce, and in some onshore areas exploration started maturing resulting in the emergence of large number of fields falling in the “Marginal” and “Sub-Economic” category. Exploration activities were spread over almost all of the today's six commercially producing basins viz. Bengal, Rajasthan, Ganga Valley, Kerala-Konkan, Kutch, Mahanadi and Andaman with varying intensity of efforts depending on the current level of understanding of the exploitation potentials of these areas. These efforts are in addition to commercially producing ones like Bombay Offshore, Assam, Gujarat and krishna-Godavari project.

The decade of late eighties has been a period of confluence of different stages of maturity of exploration. In the onshore, front ranked onshore basins (Cambay and Upper Assam) shifted to early to middle mature stage. Other three basins (Krishna Godavari, Cauvery and Upper Assam grew up into different phases of late pre-mature to early mature stages. In the offshore, the most potential search area, the “Western offshore” got into the early and mid-mature stage and the less potential Eastern offshore passed into middle to late premature stage of exploration. Field development and production activities increased in many fields and revenue earnings (and profits) touched new heights. Growth in the number of discoveries (not necessarily the big or economic) fields was phenomenal.

The decade of 80’s has been the “Decade of Prosperity”. The exploration industry reached the pinnacle and strong hydrocarbons reserve base was created to sustain production during sixth, seventh and subsequent five-Year Plans.

Present Status

The total area of the 26 sedimentary basins up to 200m isobaths is 1.78 million sq. Kms and if the deep water sedimentary areas beyond 200m isobaths is considered, it is 3.14 million sq. Km. The hydrocarbon resources for the sedimentary basins up to 200m isobath are estimated to be around 20 billion tonnes. The speculative resources for deepwater areas are put around 5 billion tonnes. As a result of sustained exploratory efforts over the last three decades it has been possible to establish hydrocarbon reserves base of around 6 billion tonnes in six sedimentary basins.

In addition there are basins where the hydrocarbon indications were encountered, viz. Rajasthan, Kutch offshore, Andaman Nicobar offshore, Punjab etc; there are frontier basins/areas which need extensive exploration like deep waters, Gondwana basins, Vindhyans, Deccan syncline etc.

Table 1.1: production of crude oil (thousands tonnes) and natural gas (million cubic meters (1975 – 76 to 1998 – 99)

State	1975-76	80-81	85-86	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99
Crude Oil Production – Onshore												
Gujarat	4148	3808	4349	6393	6035	5807	5076	6279	6362	6158	5951	4402
Assam/Naga land	4300	1712	4966	5076	4899	4986	5090	5043	5044	4796	5114	4005
Arunachal Pradesh	-	2	60	43	42	59	49	35	28	36	27	27
Andhra Pradesh/ Tamilnadu	-	-	-	313	318	352	536	656	418	382	390	336
Total	8448	5522	9345	11830	11383	11204	11651	12013	11852	11372	11482	8770
AOIC	66	48	-	-	-	-	-	-	-	-	-	-
OIL	3103	1243	2654	2649	2529	253	2811	2883	2882	2870	3094	2475
ONGC	5279	4231	6691	9181	8854	8681	8840	9130	8970	8502	8388	6295
Offshore												
ONGC	-	4985	10712	21191	18963	15746	15375	20226	22665	20183	19863	13799
Private & Joint Venture	-	-	-	-	-	-	-	-	650	1346	2514	1962
Grand Total	8448	10507	30168	33021	30346	26950	27026	32239	35167	32901	33859	24531
Natural Gas Production												
Gujarat	773	842	919	1696	1698	1946	2166	2462	2878	2932	3115	2369
Assam/	1595	843	2029	2011	31	52	47	1909	1880	1941	2018	1541

Nagaland												
Arunachal Pradesh	-	-	6	29	271	676	788	37	32	23	24	17
Tripura	-	-	-	70	-	-	-	97	131	154	196	232
Tamilnadu	-	-	-	64	-	-	-	98	117	92	95	76
Andhra Pradesh	-	-	-	46	-	-	-	640	679	799	1022	899
Rajasthan	-	-	-	-	-	-	-	-	12	10	148	121
Total	2368	1685	2954	3916	4251	4708	4979	5243	5729	5951	6618	5255
AOC	-	38	-	-	-	-	-	-	-	-	-	-
OIL	-	710	1553	1518	-	-	-	1435	1433	1467	1670	1269
ONGC	-	937	1401	2398	-	-	-	3808	4296	4484	4948	3986
Offshore												
ONGC	-	673	5180	14802	14394	13352	13356	14138	16579	16794	18102	13404
Private & Joint Venture	-	-	-	-	-	-	-	-	331	510	1681	2075
Grand Total	2368	2358	8134	17998	18645	18060	18335	19381	22639	23255	26401	20734

Table 1.2: Exploratory and development drilling by the ONGC and OIL (1975 – 76 to 1997 – 98)

Drilling (wells and meterage)	1975-76	1980-81	1985-86	1990-91	1995-96	1997-98[2]
Exploratory wells						
On shore	50#	45#	94	176	177	114
Off shore	10	16#	35	73	27	20
Total	60#	61*	129	249	204	134
Onshore	120	96	237	434	427	297
Offshore	19	40	100	184	77	50
Total	139	136	337	618	504	347
Development wells						
Onshore	69#	40*	135	220	171	135
Offshore	5	18	44	66	52	38
Total	74#	58*	179	286	223	173
Onshore	145	71	283	455	384	326
Offhsore	9	42	89	92	86	82
Total	154	113	372	547	470	408

includes : MoPNG, Indian petroleum and Natural Gas Statistics (various issues), New Delhi Econmics and Statistics Division, Ministry of Petroleum and Natural Gas, New Delhi.

Multi-national Oil Companies in India

Multinational companies like Carlesberg-Natomas and Reading and Bates were offered licenses for exploration in Bengal offshore, Cauvery offshore and Kutch offshore in early seventies. However, the efforts of these companies proved futile, as none of the multi-national companies discovered oil and gas in India after Independence. Therefore, the exploration industry was largely dependant on National oil Companies – Oil and Natural Gas Corporation Limited and Oil Isndia Limited. Roughly about 25 Million Metric Tonnes (MMT) of crude oil is produced by ONGC and about 3 MMT of crude oil is produced by Oil India Limited annually.

Currently National Oil companies ONGC and OIL are holding about 72% of the total Petroleum Exploration License (PEL) areas and Multinational and Private Companies are holding the remaining 28%. Similarly, the National Oil Companies retains 74% of mining lease areas and Multinationals and private Companies hold the remaining 26% of mining lease areas. At present, the production from joint operated fields accounts for nearly 10% of the total India's production. (Box 1.2)

Starting in 1981, nine bidding rounds for exploration blocks have
e. From 1981 to 1986, three bidding rounds were held and nine
ploration blocks were offered in Western Offshore and Eastern Offshore
areas. Multinational companies like shell, BHP and Chevron carried out
d seven wells in the offered blocks involving
$ 103 million. No hydrocarbon discoveries were
hdrew from the area.

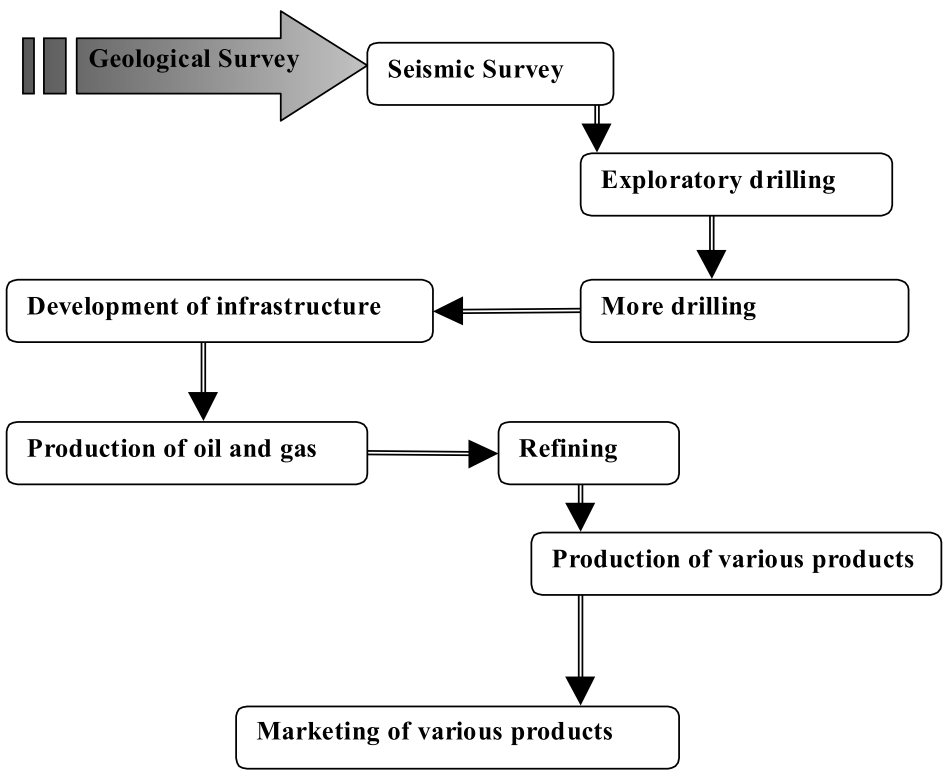
iding with the liberalized economic era in 1991, fourth round of building
regime. The last round of bidding
was for joint venture envisaging equity participation by National Oil
ranging from 25 – 40%. Simultaneously, two rounds of bidding
size fields. As a result of these
activities, about 50 exploration blocks and about a dozen medium and small-sized fields were given to multi-national companies for exploration and

An Orientation To Oil And Gas Exploration Mechanism

Exploration for oil and gas is a technology intensive and cost intensive business. A Geological survey is done of a particular area to assess the potential, followed by seismic survey. Exploratory drilling follows this, and if oil and gas are discovered, further drilling is done to assess the extent of the reservoir. Later a feasibility report is prepared followed by more drilling of Wells and oil and gas are produced after developing the infrastructure and necessary pipelines. The entire cycle takes a minimum of five years and if the results are negative at any stage, the area is abandoned and the expenditure incurred is lost. Therefore, this activity is also called a “scientific gambling”. This expenditure involved runs into crores of rupees and if succeeds, the return are also huge. Figure 2.1 illustrates the oil and gas exploration cycle. If the results are negative at any stage, the activity is abandoned at that stage.

Techniques Used In Oil And Gas Exploration:

Figure 2.1: OIL AND GAS EXPLORATION CYCLE

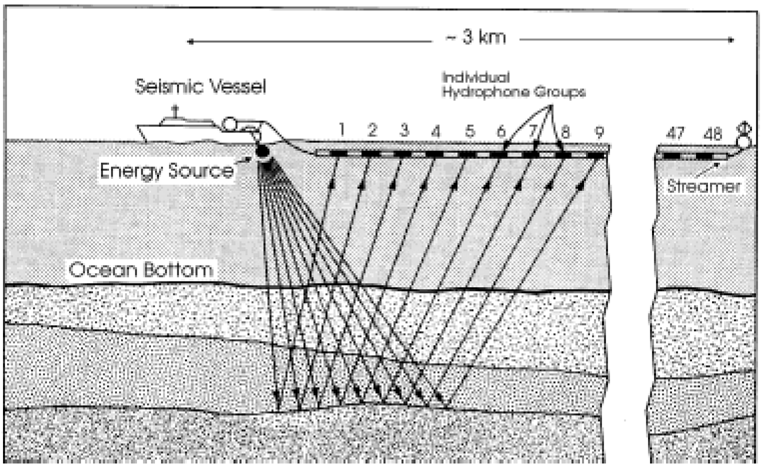


Note: *Initially, the cycle proceeds only if the exploratory results are positive. If the results are negative the operation is stopped at the stage.*

Many of the world's potential reserves of hydrocarbons lie beneath the ocean. Exploration is the technique developed by interested industry to find oil and gas and to successfully extract it for human use. Modern exploration for oil and gas relies on a solid foundation of geological and technical knowledge. In addition, today's capabilities with computers and advanced electronics, drilling techniques and methods of project management, have increased our ability to find hydrocarbons, and the speed at which projects can be developed[8]. Usually, geologists infer on exploration site from geological similarities to areas where hydrocarbons have been found before. Nonetheless, companies always run the risk of coming up empty-handed at the end of an exploration program. Oil companies use a combination of two methods viz. seismic surveys and exploratory drilling, to explore hydrocarbons under the sea.

Seismic surveys allow geophysicists to get a picture of underground rock formations. Sound waves are created by the explosive release of compressed air from an array of air guns towed behind seismic vessels (specialized ships), firing every 5 - 12 seconds. The waves bounce off layers of rock under the ocean floor, and the timing of these echoes when they are received by hydrophones* (towed microphones), shows the shape and location of the geological features. The seismic ship records the data from all the hydrophones, including accurate coordinates for the ship and its hydrophones. See figure2.2.

Figure 2.2: Seismic vessel and array mapping rock layers beneath the ocean[8]



DRILLING:

A drill site is established in about 10-15 acres area in a location identified by Geo-scientists as a prospective area for finding hydrocarbons. A drill site comprises of a

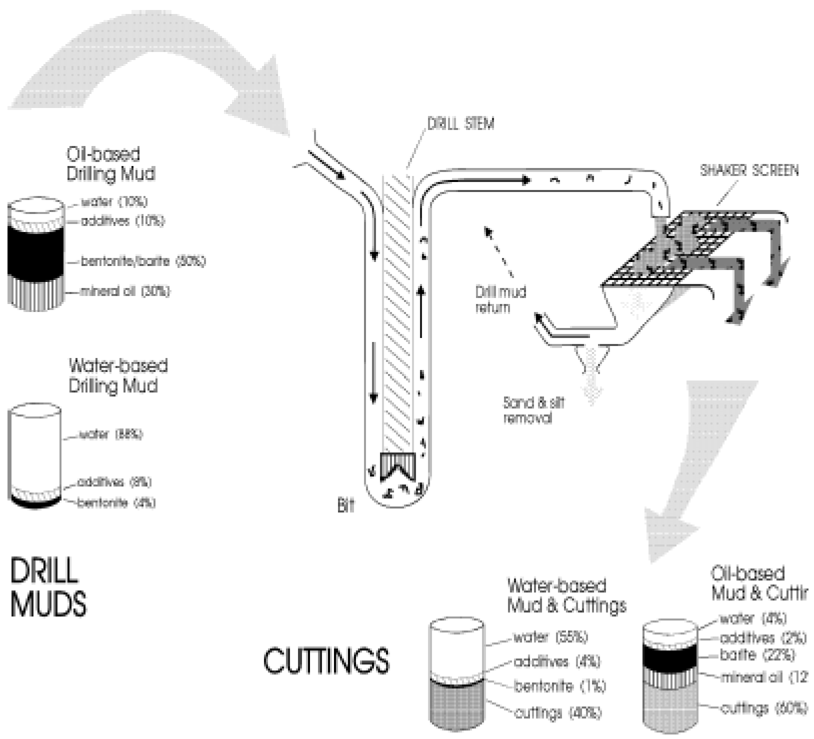
* Hydrophones are on long cables (streamers), usually at 12.5 m intervals. One or many streamers can be used; the type using a smaller number is called a *2-D* survey, as it gives a two dimensional profile. Streamers can be up to 6 km long and are stored on a large winch. hydrophones. The most sophisticated surveys employ numerous streamers and many hydrophones, providing enough data to give a detailed 3- dimensional profile of the rock layers; these are called *3-D* surveys.

giant drilling rig, and related infrastructure, which drills up to four kms, below the earth.

The following operations take place on a drilling site, which lead to land, air and noise pollution.

- A hole is drilled from surface up to the target depth, in search of or production of oil and gas. The drilling operation is planned, knowing the geology of substrata at the concerned location. Rotary drilling is usually the drilling method used to drill the borehole. (See figure 2.3)

Figure-2.3: Drilling Basics[8]



- Mud circulation programme plays a vital role in keeping the borehole stable and clean. A drilling fluid is made up of a liquid phase, some solids to weigh and some chemical additives to control the drilling activity. The main purposes of a drilling fluid are to:

- ➡ loft cuttings and clean the hole;
- ➡ cool and lubricate the bit, drill pipe, etc;
- ➡ form a filter cake against porous zones to prevent caving and formation damage; and
- ➡ prevent uncontrolled outflow of fluids.

Usually, drilling fluids are of two types (see box-2):

1. water based muds
2. oil based muds.

Oil well drilling covers a wide range of depths and temperature conditions onshore or offshore, such as:

- ➢ High temperatures upto 50^0 F approximately
- ➢ High pressure upto 30,000 psi approximately
- ➢ Depths upto 5000 metres (5 Kms.) below the earth surface

Many chemicals are used as additives to

- ♠ control alkalinity or pH of the mud;
- ♠ to reduce bacterial growth;
- ♠ remove calcium effects while drilling through anhydrite and gypsum formation;
- ♠ inhibit corrosion;
- ♠ de-foam the mud, specially when brackish waters and saturated salts muds cause problems;
- ♠ Flocculate the mud for increasing its gel strength; and lubricate the bit, etc.

Technical and Socio-Economic Survey

For the purpose of survey, two onshore areas were chosen. In Andhra Pradesh, ONGC is exploring in the Krishna-Godavari basin, which is spread around the town Rajahmundry and eight rigs are operating presently. Similarly the sites are chosen from drilling operations taking place in Assam.

Table 1.3: Summary of the exploration and production process

Activity	**Potential requirement on ground**
Desk study: identify area with favourable geographical conditions	None
Aerial survey: if favourable features revealed	Air-craft
Seismic survey: provides geologic information	Navigational beacons, seismic lines, operation camps
Exploratory drilling: verifies the presence/absence of hydrocarbons	Storage facilities, waste disposal facilities, Accommodation, testing capabilities
Appraisal	Access to drilling sites, storage facilities, etc.
Development and production	Well heads, flow lines, Gas production plants, transport, infrastructure, flares
Decommissioning and rehabilitation	Equipment to plug wells, decommissioning and restore of sites

The scope of work includes, (i) collecting and analyzing water samples in water column for monitoring hydrographical, chemical and biological characteristics including pollutants like petroleum hydrocarbons and heavy metals, (ii) collecting and analysing sediment samples for quantifying hydrocarbons depositions, heavy metal concentrations and benthic biota, (iii) collecting and analysing a few samples of zooplankton and fishes in the vicinity of oil fields to understand and estimate the possible bioaccumulation of pollutants. The next state of work involved was field visits to gather information on selected indicators. Observations were made on in site operations to examine the cause and effect relationships. Some additional data were collected regarding the reservoir characteristics, rate of production, and levels of associated gas, geological formation, and equipment used at the site. However, the equipment used at the site. However, the focus was on the waste disposal and management at the site – on shore and off shore.

Finally a socio-economic survey was conducted to study the impact of oil and gas explorations. The results were analysed. A regulatory monitoring mechanism for the overall oil and gas exploration and production activities was suggested.

The forthcoming sections discuss the methodology adopted for the study, the results of the survey and policy recommendations.

CHAPTER 2: IMPACT OF OIL EXPLORATION ACTIVITY ON ENVIRONMENT

Oil and gas exploration requires power generation and supply, infrastructure development, besides many other activities together with the consequent influx of people makes the exploration sites vulnerable to environmental degradation. The intensity of such activity can produce a variety of effects that vary with time and distance from the development site. The board environmental issues faced by oil and gas exploration and production industry are manifested in both local and global levels. The effects may at times be far from the point source, for example contamination of water sources, changes in land-use, caused by access routes. They also include habitat protection and biodiversity, air emission, marine and freshwater discharges, incidents of oil spills and soil and ground water contamination. It is therefore important to consider immediate, short-term impacts as well as long-term, indirect and cumulative impacts from separate, but linked operations.

In the eighties, India was becoming increasingly self-reliant with respect of crude oil and petroleum products. Infact there was a gradual increase in the production of crude oil and natural gas production from 1975 onwards till about the 1998. This was owing to the increase in the exploration and exploitation of petroleum resources. This increasing trend in petroleum production resulted in considerable concern to the likely impact on the environmental conditions. The major by-products of oil field operation include oil field brine, oil-bearing water and oil drill mud. All these by-products require adequate treatment and safe disposal in order to prevent environment being contaminated with the offensive substances present in these by-products. With the concern of environmental protection and the introduction of the new regulatory guidelines for the exploration resulted in taking adequate safely measures in disposing the wastes. There are, mainly three types of emissions from upstream oil operation i.e., emissions to air, discharge to water, and waste disposal of cuttings.

Oil Industry and Air Emissions

The majority of air emissions are from production side due to controlled flaring and venting which are necessary for safe operations. Sometimes accidental discharge from well during blowout / fire emits large amount of gases such as sulphur dioxide (SO_2), carbon monoxide (CO), hydrogen sulphide (H_2S), and the other oxides of nitrogen as well as particulate containing partially burnt hydrocarbon and metals. All of these are potentially hazardous to human health and vegetation growth. The most important components of emissions to air are carbon dioxide (CO_2), nitrogen oxide (Nox), methane (CH_4) and Non-Methane Volatile Organic Compounds (NVOCs). Both onshore and offshore oil exploration activities constitute an important source of emissions. They include,

- Flaring, venting and purging gases, including black smoke emissions
- Dust from mud preparation and cementing operations and from movement of heavy equipment
- Smoke from pump engines and generators
- Carbon monoxide and hydro carbon released by incomplete combustion
- Nox and Sox produced from exhaust of internal combustion engines
- Fire protection systems
- Fugitive gas losses

Effect of Exploration and Production

There is considerable impact from oil exploration and production activities to the both regional and global environment. One way to begin and assess this aspect is to look at the emissions, both in terms of their effect and quantity. Although emission data for the industry worldwide not available, some companies are now publishing these data. The data reported here is from BP's (BRITISH PETROLEUM) *New Horizon* annual HSE (Health Safety and Environment) reported published as part of a policy to improve communication of the company's HSE performance showed in the following table.

Table 2.1: Emission in terms of effect and quantity

1994	
1. Emission to air (m tons)	
VOCs	19,528
Methane	16,942
Sulphur oxide (SOx)	1,588
Nitrogen oxide (Nox)	25,821
Carbon monoxide (CO)	13,658
Particulate	398
Total emission to air (m tons)	**77,933**
2. Discharge to water (m tons)	
3. Oil in produced water	1293
Oil on mud and cuttings	1295
Total oil discharged to water (m tons)	**2578**
3. Total on site disposal	0
Total offsite disposal	**43,036**
TOTAL EMISSION AND DISCHARGE (m tons)	**1,23,547**
TOTAL PRODUCTION (million tons)	**1,20,253,000**
EMISSION AS A PERCENTAGE OF PRODUCTION	**0.1%**

Quantum Of Emission

As it can be seen from Table 2.1, emission from exploration and production activities is 0.1% of the actual production and represents a very small percentage. Most of these emissions (60%) are atmospheric and one third are solid and only 1-2% are discharges to water. Almost half of the emissions are hydrocarbon consists predominantly of methane. The remaining emissions, principally NOx , SOx and Co are produced during fuel combustion. CO_2 is not included in this data set because its impact is much lower on a per ton basis. Even though the units appear to be different the data is totally converted into million tons equivalent and reported here.

The above data is illustrated in the following two figures. Atmospheric emissions are the highest of the order of 63%, followed by soil with 35% (figure 2.1). Similarly, fig.2.2 shows components of air pollution at the exploration and production stage.

Fig 1: Emissions Profile – exploration & production

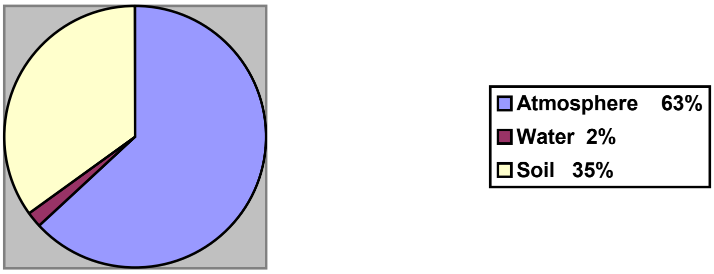
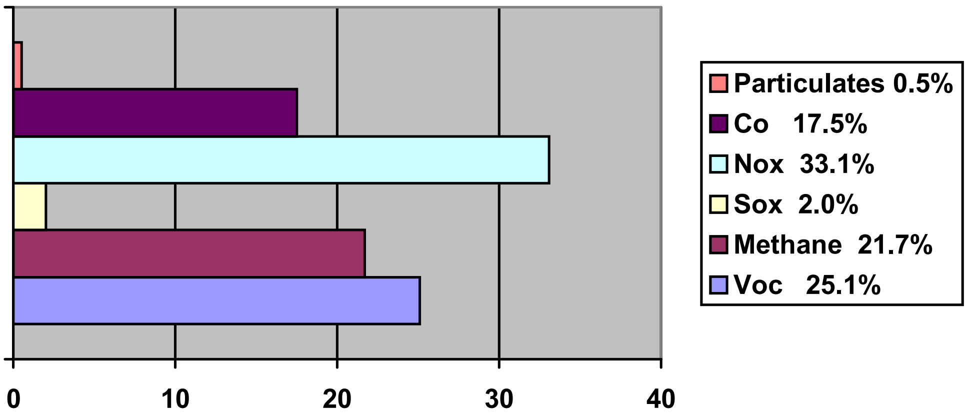


Fig 2: Exploration and Production air emission component



Effect Of Emissions

- Volatile organic Compounds (VOCs) – The principle effect of VOCs is their local ambient ozone – forming potential in combination with nitrogen oxides and sunlight. Ozone can affect the respiratory system in humans and affect plant growth. Methane can be considered separately from other VOCs as its main impact is its global warning potential, which is second only to that of carbon dioxide.

- Sulphur oxides (Sox) – Sulpur oxides lead to acid rains. This may corrode buildings, increases the acidity of poorly buffered soil, reduction of forest life and marine life.

- Nitrogen oxide (Nox) – Along with VOCs and sunlight, Nox can combine to increase ambient ozone that causes photochemical smog, particularly where there is no air dispersion. Inhalation of NO and NO_2 can affect the respiratory system directly.

- Carbon oxides (CO_2 / CO) – Carbon dioxide is the predominant green house gas which could bring about global climate change. Carbon monoxide increase the lifetime of VOCs by atmospheric chemistry and also produces ozone in its own, although slowly.

- Hydrocarbons in water – There are different effects from lowering the oxygen level in water due to bio-degradation, to the gross contamination caused by oil spills. Contaminants in the soil can leach into ground water and thereby pollute potable sources. Some aromatic hydrocarbon components are toxic to aquatic life.

Oil Industry and Noise

Noise is an unwanted sound. Noise pollution can result from various activities related to drilling operations, exploration activities, vehicular movements and production operations. Noise affects not only humans but also wildlife. Loud sounds used in seismic surveys during the exploration can have a range of effects on living creatures, depending on how close to the source they are.

During seismic surveying underwater explosions of around 250 decibels (the human pain threshold is at 140db) are created with air guns. This has a particularly disturbing effect on cetaceans, who use sound for communication and navigation, and may even be responsible for whale grounding. Fish are also displaced, which in turn affects the cetaceans and birds, which feed on them. The blasts can damage tissues, including lungs, guts and ears in mammals, and swim bladders in fish.

With in a few meters of the sound source, aquatic organism can be killed or injured. Thus the impact of oil and gas exploration is of varying magnitude both on socio-economic and environmental parameters. However, the threshold, also varies from place to place.

Oil Industry and Hydrological Impacts

Aquatic ecosystems are a major concern from the pollution arising out of oil and natural gas production, as it involves varies activities that affect the normal functioning of water ecosystems. The potential affect of water resources, both ground and surface waters needs to be evaluated for any major impacts by the operations, particularly where local people, fisheries and wildlife populations use water.

Excavation and infill can use significant alternatives to the existing water sources and drainage patterns, which can lead to marked changes in the floral and faunal diversity in the vicinity. Further operational activities can also introduce contaminants into the aquatic environment. Sensitive wetland communities are also susceptible to pollution arising from the various activities related to petrol exploration. The principal aqueous waste streams from oil and gas operations are:

- Produced water
- Drilling and well treatment fluids
- Process, wash and drainage water

Specific impacts may include,

- Alteration of drainage patterns due to topographical changes
- Creation of water, pond-dominated landscapes by topographical changes
- Creation of higher, drier landscapes by introduction of fill material into surface water overlying permafrost
- Direct and indirect impacts to water supplies by clearing of vegetation
- Discruptions to surface water movements and changed in quality by vehicle traffic, removal of vegetation and impounding

- Contamination of ground and surface water by drilling fluids and oil during the drilling of wells

- Contamination of ground and surface water from operational discharges, leakage, site drainage and accidental releases.

Water bearing formations in the surrounding areas may also be spoiled by seepage of water containing dissolved salts and mud chemicals from drilling. Mud stored in pits around drill sites, oil spills on land and on water may damage the ecology of the surrounding area and the waste products produced during these operations may pose problems in there disposal.

Impacts on Marine Life

Study in terms of conducting experiments to assess the impacts of pollutants on marine life was out of the scope this study. Therefore, the literature – based approach was adopted; wherein the conditions similar to the study site were taken into consideration and the result was extrapolated in order to get realistic outcome. Though wherever possible details about impact were collected during fields visit by interview, they were found worth depending on. Since livelihood of many people along the coast is depending on fish and other fauna they are very concerned about their well being. This aspect helped is to know more about impact of exploration activity on marine life.

Impacts on Soil Ecosystem

The extent of nay disturbance on soil will depend on the soil type and the geology of the area. Since soils have a low resistance to degradation and are vulnerable to changes in temperature, and chemicals introduced by the various human activities it can dramatically reshape the land. The most significant potential effects of oil and gas development activities on soil include:

- Compaction

- Contamination from various operational discharges, leakage, site drainage and accidental releases.

- Changes in the drainage patterns

- Erosion resulting change in the landscape and pooling of water

Impacts on Biodiversity

Flora

Loss of fauna is of great concern in any oil exploration site. The disturbances of the ecosystem lead to a slow recovery owing to long gestation periods. Further loss of vegetation also affects nutrient cycles, removes the organic litter, accelerates soil erosion, reduces the availability of habitat for wildlife. Vegetation can also be lost or altered due to construction activities for access roads, drilling and production sites, support infrastructure, borrow sites, as well as habitat structure, prolonged changes in vegetation cover can disturb the ecosystem stability considerably possibly beyond redemption.

Fauna

Animal populations are largely affected by the changes in vegetation, soil, water and noise levels arising from these activities due to changes in – habitat, food supplies, migration routes, breeding areas, vulnerability to predators or changes in herbivore grazing patterns etc. Some of the major effects of exploration and production activities on wildlife include:

- Displacement in the immediate vicinity
- Habitat disturbance
- Direct habitat loss and modification
- Blockage of access to habitats

Habitat losses or modification could result from loss of certain ‘key stone or endemic species resulting in irreversible loss in diversity. Also habitat disturbance could include vegetation or soil removal, erosion-changes in soil structure, changes in topology, sedimentation, and hydrology. Access to habitats can be blocked by the construction of roads and pipelines. It is important to note that changes in the abundance and distribution of certain wildlife species can have significant impacts on the livelihood of indigenous people as well. Therefore its important to consider, to the extent possible on the basis of existing knowledge when evaluating the likely effects of development on biodiversity that include:

- Rate of extinction occurring and likely to occur
- Minimum sustainable gene pools and population size
- Dynamics of ecosystems that support threatened or endangered species
- Status, distribution and vulnerability of individual species
- Regional differences in extinction rates

Drilling Operations and Environment

The technology of mud mixing and treatment is generally recognized as a major source of pollution from various pollutants such as barium, mercury and cadmium, diesel (from lubricants, spotting fluids and oil based mud cuttings), arsenic and formaldehyde (from biocides). A typical elemental composition of common constituents of water based drilling mud is given in Table. 2.2. Further composition is also related to the performance requirement although it varies with well depth, direction and location. The commonly used type of water based mud drilling under many conditions is lignosulfonate mud where the basic additives are barite, bentonite, caustic soda, lignite and chrome lignousulfonate.

Environmental Components in Drilling Process

The board environmental issues faced by the oil and gas exploration and production industry are manifested at both local and global levels. The disruption of the ecological balance through drilling operation occurs through surface discharge of pollutants from various activities affecting the environment. Environment management of drill sites is a serious problem to combat drilling pollution both at onshore and offshore. Discharge of untreated drilling effluents into seas, rivers or land constitutes a serious health hazard, and is detrimental to agriculture and fishes. During water can get contaminated. Destruction of environment will lead to the destruction of all life. The most important concern relates to the degradation of land, water and air around drill sites.

Drilling Mud

During the drilling operations some of the mud is discarded due to increase in volume and less storage capacity. Typically, drilled solids (cuttings) usually compose clay, clay stone, sand, gravel's, coal and limestone etc. with small quantities of other minerals, depending upon the geological formation at a particular site. During drilling these solids are brought to surface, by drilling fluids and dropped on the vibrating screens of the shale shaker, were bigger size solids are removed and separated from the mud.

Most of the mud systems having stronger inhibitive properties are shown to be more toxic. Polymer muds have traditionally been the best water system with the lowest dispensability. Howerver, the toxicity limitation of a minimum LC50 value of 30,000ppm essentially eliminates potassium from use. High salt (NaCl) polymer muds are therefore, being used and a variety of additives based on glycerol and glycol chemistry have been developed and being used. The recently developed 'cationic' mud systems appear to have low dispersibility and toxicity. These systems are usually formulated using non-reactive sepiolite or attapulgite clay cationic polymeric extender and cationic inhibitors so that the solids in suspension are positively charged. Negatively charged reactive cuttings are encapsulated by adsorption of the cationic inhibitor on their surfaces thus preventing their disintegration.

Hydrocarbons, Chloride Salts and heavy Metals

The most common environmentally objectionable elements in during fluids occur naturally. However, manmade contributions that would exceed the natural levels are controllable and generally can be eliminated or reduced to a minimum.

Hydrocarbons are normally an undesirable material in water base drilling mud because they contaminate cuttings. They enter mud while drilling through a hydrocarbons bearing formation or when oil is used for a spotting fluids when a pipe becomes stuck. In general, the deeper the well, the greater is the concentration of hydrocarbon that enters the mud.

Salts are another unwanted components of drilling fluids at disposal time, which are often added to protect sensitive formations from reacting with the drilling fluids. The salts concentration also increases significantly if a well is drilled through a salt zones or a formation having water with a high salt concentration. In on-shore drilling, chlorides above these “background” levels are not needed. Potassium chloride is sometimes added to control problematic shale formations. Potassium acetate or potassium carbonates are acceptable substitutes in most situations.

Heavy metals are present in drilled formation solids and in naturally occurring materials used as mud additives. The less used chromium lignites (trivalent chromium complex) are similar in chapter and performance. Typical chromium levels in mud are 100 to 1000 mg/l. zinc compounds, such as zinc oxide and basic zinc carbonates, are used in some drilling fluids. Recently attention is being focused on the heavy metal impurities in drilling sites. However, the environmental effects of these heavy metals impurities depend upon their bioavailability that varies from one metal to another. Another significant source of heavy metals in drilling fluids is the thread compound (pipe dope) used on the pipe threads that contain as much as 60% of metals by weight, used as lead, zinc, copper or combinations of these metals. These metals are a threat as they leach out of the pipe dope and contaminate the drilling fluids.

Additives and its effects

Before 1980, many types of mud used would have exceeded the 30,000ppm limit imposed for discharges. The drilling fluid companies developed lower toxicity solutions to the problems that require special additive. The problems include foaming, excessive torque and drag friction, corrosion, bacterial attack and stuck drill pipe. Petroleum based lubricants have been replaced by low toxicity glycols, chromates are avoided as corrosion inhibitors. Halogenated phenols are no longer used, formaldehyde releasing compounds are being replaced with more acceptable bactericides. Although there is stillroom for environmental improvement in specialty additives, the progress has been remarkable.

Toxicity

The toxicological characteristics of a drilling fluid are determined by its composition. Generally there are three contributory factors of toxicity in drilling waste:

a. The chemistry of the mud formulation,
b. Inefficient separation of toxic and non-toxic components and
c. The characteristic of drilled rock.

Table: 2.2: Drilling mud additives used in drilling operations

Sl. No.	Name of Additive
1	Aluminum Stearate
2	Attapulgite Clay
3	Bagasse (Dried sugar cane)
4	Barium Sulfate
5	Bentonite
6	Calcium Crabonate
7	Causticised Lignite (Sodium lignite)
8	Cellophane
9	Chrome free Lignosulfonate
10	Cotton seed pellets
11	Diamines and fatty acid amides
12	Detergents
13	Ethylene oxide adduets of Phenol and nonylphenol
14	Guar gum
15	Hydroxythyl cellulose
16	Lecithin
17	Lignite
18	Magnesium oxide
19	Methane
20	Mica
21	Morpholine polyethoxyethanol
22	Nut Shells
23	Paraformaldehyde
24	Peptized acid
25	Phosphoric acid
26	Polyacrylamide resin
27	Polyaniocin cellulose polymer
28	Polysaccharides
29	Potassium chloride
30	Potassium hydroxide
31	Potassium sulfate
32	Pregelatinised corn starch
33	Qartz or cristobalite
34	Rice husks
35	Saw dust
36	Shredded paper
37	Sodium acid pyrophosphate
38	Sodium bicardonate

Sl. No.	Name of Additive
39	Sodium carbonate (Soda ash)
40	Sodium carboxymethylcellulose
41	Sodium chloride
42	Sodium hexametaphosphate
43	Sodium hydroxide (caustic soda)
44	Sodium montmorillonite clay
45	Sodium polyacrylate
46	Sodium tetraphosphate
47	Starch
48	Tetrasodium pyrophosphate
49	Tributyl phosphate
50	Vegetable & polymer fibers
51	Vinyl acetate
52	Xantham gum (xc polymer)

Volume and toxicity are two environmental risk criteria for evaluating drilling waste discharge. A steady built up of the mud system volume is inherent in the drilling process and results from both the disintegration of cuttings during that transport to the surface and the limited efficiency of cutting removal by the mechanical solid control separators. The ultimate disposal of this wastes depend upon the toxicity of mud systems used to drill the well. Therefore, the properties of mud systems that are directly related to pollution are dispersibility, dewaterbility and toxicity.

The toxicity in the water is measured by the fish tissue culture based on 96 hours of survival in an experimental station. The biochemistry analysis based on this analysis is reported in the following table – toxicity of drilling mud additives.

Table 2.3: Toxicity of Drilling Mud Additives

MUD TYPE	96-hr LC_{50} (ppm)
Potassium Chloride polymer	33,000
Lignosulfonate seawater	621,000
Lime	203,000
Lignosulfonate freshwater	300,000
PHPA 9.6 lbm/ gal	>1,000,000
PHPA 14.3 lbm/ gal	>1,000,000
PHPA / 20%NaCl / 14.5 lbm/ gal	140,000
PHPA seawater 13.5 lmd/ gal	>1,000,000
Cationic Mud	>1,000,000
Freshwater Chrome- lignosilfonate – 2% diesel	5,970
Freshwater Chrome- lignosilfonate – 2% mineral oil (15% aromatics)	4,740
Freshwater Chrome- lignosilfonate – 2% mineral oil (0% aromatics)	22,500
Mineral Oil	180,000

Dewatering of Drilling Fluids

A zero discharge system or dry drilling location requires advanced technology for mud processing and one such technology is mud dewatering which separates water from water based muds. The process of dewaterability involves the ability of drilling fluid suspensions to destabilize and release their water phase. The treatment consist of chemical destabilization, in which a uniform liquid suspension is converted into two phases, free water and flocculates; and mechanical expression in which additional water is released by squeezing the solid structure. Dewatersbility can be determined simply by measuring relative volume reduced after squeeze. The water from such a process contain wide array of environmental pollutants in various quantities.

Waste characteristics

The major sources wastes include the inorganic and organic additives used in drilling mud, friction reducer, additives for fluids loss control, varieties of inhibitors and additives added to control the properties of acidising fluids that may find their way to the environment. Oil fields brine with high dissolved solids, if allowed to flow freely over cultivated land, may ruin the vegetation and render the land completely useless for further cultivation. Oil field operation constituting major pollution are: seismic shot holes, wastewater disposal of drilling mud and oil spills during transportation of oil on land and water, improper disposal of drilling mud and oil fields brine leading to a number of environmental pollution problem. If these pollutants are improperly disposed or disposed with out giving adequate treatment they affect our environments.

Waste Disposal Practice

At the time of drilling a sizable amount of mud is collected (slurry) and discharged into the open areas. This mud waste contains hazardous substances such as nitrogen, oily waste, paint thinner, paper, card board, glass etc., pipe dope (lead, zinc, or copper based), propane, rig wash (sodium carbonate, sodium meta silicate); scarp plastics, lime oxygen scavenger; soda ash; zinc carbonate etc. These mud and waste chemical compounds are discharged into the nearby fields, thereby damaging the nearby crops, flora and fauna of the area.

Spent drilling fluids and cuttings disposal are in accordance with regulatory requirements that vary with area. The most common practice for onshore wells involves on-site reserve pits. The reserve pits however, cause local environmental impacts. The composition of the fluid in a reserve pit may be different from that of original drilling fluids because of heat, pressure and addition of formation materials. Bad storage and disposal practice, commonly associated with reserve pits, lead to their being a source of benzene, lead arsenic and fluorides even when these components are not detected in the active mud system.

Land Farming involves even distribution of mud and cutting onto surface soils and their mechanical incorporation into the soil. Tilling of soils allows faster biodegradation of any hydrocarbons and greatly dilutes the impacts of trace metals or salts. Solidification of drilling waste requires mechanical equipment and cementing chemicals. The environmental problems, thus, have stimulated new developments in drilling fluids technologies.

Oil and Grease Discharge

Lubricating oil and grease are primarily used for machinery, while graphite is used for machinery, while graphite grease is used in joint of drilling pipes. Gear oil and HSD oils are used in engines and generators and for various other drilling purposes. During washing with water, discharges find their way to waste pit, and floats on the surface of water thus causing serious environmental concerns. Also in producing oil fields, large volumes of water are produced from the sub-surface oil reservoirs which are usually called oil brine, that has the presence of high quantities of soluble mineral salts in which the principal cations may be sodium, potassium, magnesium and calcium while the anions include chloride, sulfate and bicarbonate.

Typically the concentration of dissolved salts may extend from about 1000mg/l to about 3,00,000 mg/l. Beside the brine also carry finely divided sand and salts, precipitated salts, oil, bacteria, organic complexes, hydrated iron oxide etc in suspension causing environmental concern. Oil, another component associated with brine and separation of oil must be performed before the brine can be disposed off in a satisfactory manner.

Oil Pollution due Offshore Exploration and Spills

Oil seepage normally occurs beneath the sea as direct source of pollution. Oil forms formed due to oil exploration activities, unsafe disposal activities and accidental spills often result in forms floating on the adjoining surface water are carried by the winds to the adjacent shores hampering the functioning of surrounding ecosystems. A major oil spill on internal water or offshore waters or a discharge of any size of such nature and quantity affects human and welfare substantially. Oil leaks from transmission system is another source of oil pollution.

Off shore disposal

Offshore disposal of waste generated have two alternatives regarding disposal of drilling fluids and cuttings disposals, either to discharge from the platform or during the transport to shore for ultimate disposal upon suitable treatment. While some pollutants are easier to regulate but some long chained compounds, glycerols are difficult to subject to any kind of treatment. The normal recommendation for the disposal of drilling fluid is by dilution using seawater (quantity, depending on the composition of the pollutants). The solid are either treated separately or discarded.

Onshore Disposal

During drilling operation, hydrocarbon and heavy metals found in the mud additives gets accumulated in the waste pits, posing serious threat to the aquifer in the region. Some of the heavy metals that are toxic include chrome, mercury, and cadmium.

Since drilling fluid consists of heterogeneous mixture of chemicals that vary in quantity and quality therefore its treatment before discharging needs to be carefully considered. For instance the fluids and solid present in the waste pits must be tested for heavy metal concentration before disposal. The most common form of shore disposal of non-hazardous drilling fluids is dewatering followed by disposal to land (i.e. land spreading, land farming or land filling) pits must be lined to prevent seepage and contamination of ground water (especially from heavy metals).

CHAPTER 3 : METHODOLOGY

Increased environmental concern and strict legal regulation adopted in exploration 'business' around the world has opened new avenues for many researchers to work on the possible effects of oil and gas exploration on different dimensions relating to environment and human societies. As a result, different groups adopt different approaches in order to assess the impact of this 'activity' on the environment and humanity at large.

The process of production of oil and gas as a whole is complicated leading to both direct and indirect impacts, at every stage viz. Exploration, production and refining or accidents, which never come with pre warning, making the entire process modeling a difficult exercise. The present chapter deals with the methodology adopted in order to study and assess the impact of oil and gas exploration activity on the environs. In order to assess the actual impact a study with the following objectives were undertaken.

Objectives

The main objectives of the study are to:

- Assess the effluents and other substance discharged in the neighbourhood of the drilling site;
- Assess the linkage of drilling activity with the environmental degradation;
- Developing a data base to monitor various types of pollution from oil and gas production which includes social costs,
- Identify regulatory mechanism and guidelines for oil industries in India
- Evolve a methodology, for environmental damage caused by blow out of gas wells; and
- Suggest policy guidelines for the reduction in environment damages.

Design of the study

The study started with an overview of oil and gas exploration activity. This included collection of secondary data from various sources to assess the impact of effluents and other substances discharged in the neighborhood. A quantitative assessment of this data (depth, type of substance discharge in the air, water, and soil) helps in linking drilling activity with the environmental degradation. After careful study of the existing reports and data collected the output was brought out. Socio-economic perceptions and the environmental awareness of the local people were captured through a structured questionnaire.

The output of the study contain:

➔ Database at the drilling activity and the associated pollution levels based on the primary data,

➔ Socio-economic characteristics of the region – survey and analysis, and

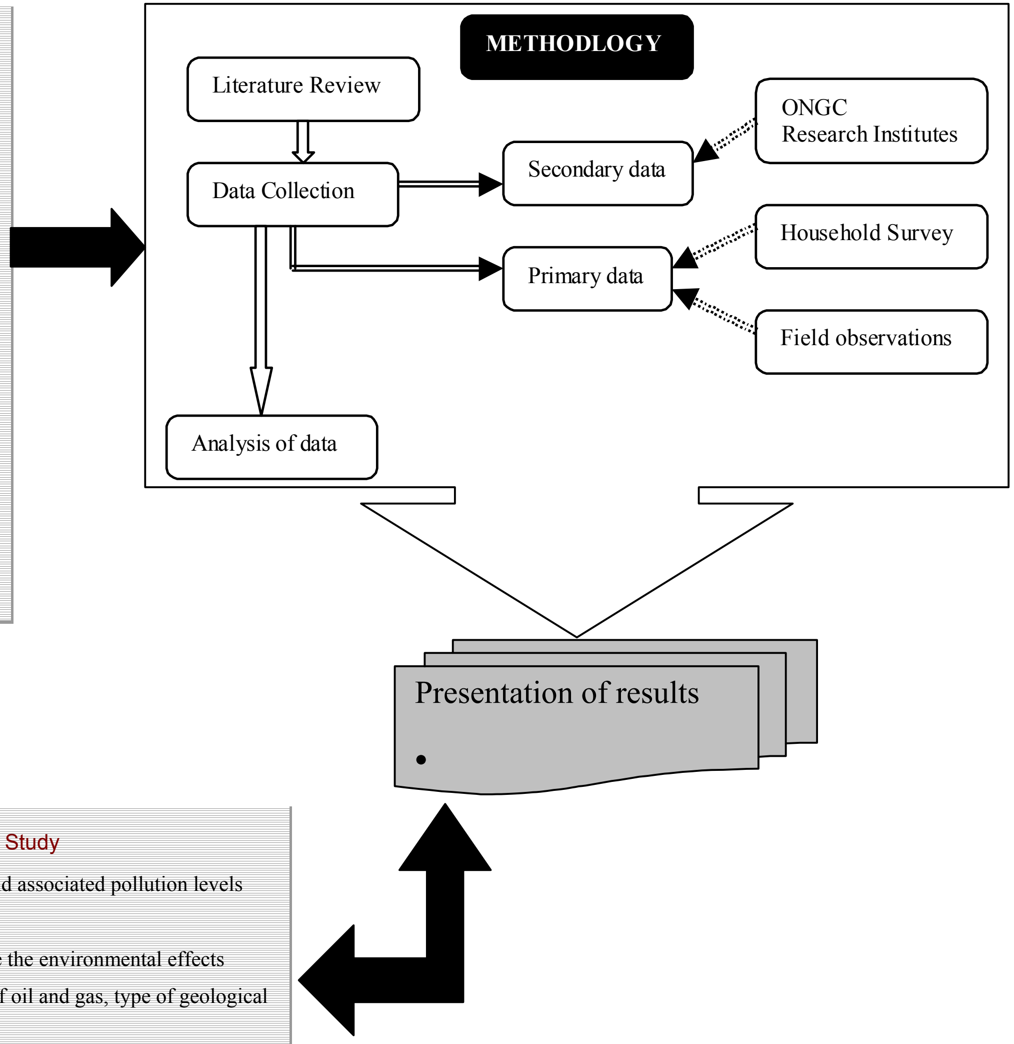
➔ Policy recommendations.

The following section deals with the approach adopted to deal with these issues. Figure 3.1 systematically shows the flow of the different activities and the design of the study.

FIGURE-3.1DESIGN OF THE STUDY

Objectives

- to assess the effluents and other discharge in the neighborhood of the drilling site
- quantitative assessment of the type of drilling - depth, type of substance discharge in the air, water, and soil
- linkage of drilling activity with the environmental degradation
- developing a model to monitor various types of pollution resulting due to oil and gas exploration which includes social costs
- to identity regulatory mechanism and guidelines in India in relation to the similar regulations in place in other countries for the waste management
- evolve a methodology for environmental damage caused by blow out of gas wells; and
- suggest policy guidelines for the reduction in environment



Output of the Study

- database at the drilling activity and associated pollution levels based on the primary data,
- an econometric model to simulate the environmental effects depending on the depth, quality of oil and gas, type of geological formation etc.,
- an environmental impact assessment model based on the historical data linked with the primary information; and
- Socio-economic characteristics of the region.

Data Collection

Source of Data

As a part of the first stage of the study, to develop quantitative indicators, a survey of literature has been undertaken extensively. Firstly, the types of pollutants that come out of drilling activity are identified. Secondly, the type of pollutants that come out of onshore and offshore operations are distinguished. The information is based on existing literature and field visits to the Oil and Natural Gas Corporation (ONGC) establishments, Research Institutes (such as the Institute of Petroleum Safety and Environment, Goa, National Institute of Oceanography, Goa and Institute of Oil and Gas Production Technology, Mumbai, KD Malaviya Institute of Petroleum Exploration, Dehra Dun, and the Institute of Engineering and Ocean Technology, Mumbai) The major environmental issues that are dealt here include:

- Water Pollution
- Air Pollution
- Noise Pollution
- Land Pollution
- Impact on marine flora and fauna

A quantitative assessment of data on these variables (depth, type of substance discharge in the air, water, and soil) helps in linking drilling activity with the environmental degradation. A mathematical model has been developed to monitor pollution activities at drilling sites.

The study on the socio-economic survey was undertaken to get representative sample based on the published sources and through field visits in Krishna Godavari Basin, Assam area and Costal Maharashtra region. A pilot survey of the household indicated that social, physical and economic characteristics of human population appear to be related to the affected person. Through the field survey data were collected from three villages namely Karavaka, Keshanapalli and Ethakota in Andhra pradesh, two villages namely, Hatipati and Konwarpur in Assam and one village Jangir in Maharashtra. The households were chosen using random sampling techniques. Clustering of households became necessary in order to reduce the cost/time of data collection to manageable proportions. Using this method, the survey was done in the following manner.

The primary data were collected from field survey with the primary data collection focused on:

- ➔ Socio, economic and environmental inventory of the region under study
- ➔ Peoples knowledge and perception about exploration and related activities
- ➔ Actual impact on people living in the vicinity
- ➔ Impact on marine life
- ➔ Benefits of exploration activities to the common people
- ➔ Efficiency of different activities during exploration
- ➔ Accidents related information
- ➔ Type of chemicals released during different stages of exploration and their visible and invisible impact on environment.

Mode of Survey

The household survey was based on personal interviews. A structured questionnaire containing details of households, family size, family income, perceptions of environmental effects and other related information which people thinkimportant for them etc. The "*random sample survey"* method was adopted in order to cover broad range of income categories and their perceptions about the oil exploration in the region. The households were asked to specify the effects of oil exploration on social, economic and environmental conditions. Before the interview, the households were briefly about aim and importance of the survey.

Socio-Economic Survey

The environmental impact of oil and gas exploration provide an important aspect of socio-economic activities of the community in the villages surveyed. In addition to environmental aspect. This socio-economic survey was conducted at three different geographical locations to assess the impact of oil and gas drilling on the living conditions of the people in the neighborhood of the exploration activity. Since the drilling sites being very large spreading across a wide area, a sample coverage of some of the areas covering households and bears a close resemblance to the total system was ensured.

Study area:

Three geographically and environmentally different locations were chosen to assess the impact of exploration activities in the country as a whole. We selected a total of six villages covering different locations within the country.

Table 3.1: Villages sleeted for study

Region	Name of The State	Name of the study site/ Village
South	Andhra Pradesh	Kesanapalli
		Karavaka
		Ethakota
		Rajahumundry
Northeast	Assam	Konwarpur
		Hatipati
		Geleki
Eastern	Maharastra	Raigad District

The location is Rajahumundry in Andhra Pradesh, where the drilling sites are in the midst of paddy fields, coconut trees and rich commercial crop fields surrounded by greenery. The village in Raigad District of Maharashtra is located in costal belt.

A sample of 20 households was selected from each of these villages covering various categories depending on their income, land holding, age etc. The survey was conducted during April-December, 2000.

TECETRO ECONOMIC SYRVEY

This study was designed to find out the techno-economic as well as socio-economic impacts of Oil and Gas exploration and view it from the perspective of the decision-makers as well as local people. This is necessary to throw light on the perceived environmental impacts of oil and gas exploration, the awareness of people and the long-term implications of exploration activities.

The technical survey comprising of three villages from Andhra Pradesh (Kesanapalli, Karavaka and Ethakota), two villages from Assam (Konwarpur and Hatipati) and Mumbai High was conducted. The surveyors visited the drill sites at the five locations and administered the questionnaire to the technical personnel at the drill sites. Information was obtained pertaining to the details of the drill sites. A total of 15 installations including the group gathering stations were observed and the data was analysed.

CHAPTER 4 : ENVIRONMENTAL IMPLICATIONS – A TECHNICAL ANALYSIS

This study was designed to find out the techno-economic as well as socio-economic impacts of oil and gas exploration and view it from the perspective of the decision makers as well as local people. This chapter deals with environmental impacts during the variousstages of oil and gas exploration. This technical analysis is confined mostly to the site near Kesanapalli in the state of Andhra Pradesh. Other villages include Konwarpur and Karavaka. The villages for the study are chosen on account of the number of wells drilled in the villages. The old drilling area in Assam has the maximum number of drilling sites. In Assam a total of 150 drilling rigs were there. In the recently developed area like Krishna Godavari basin relatively few wells are operating. Here a total of 106 rigs are operating. This information is in conformity with the years of operation in these areas.

Water

Aquatic ecosystems are dynamic systems that constantly change, as results of external influences. In any environmental impact assessment study, the water quality changes both in surface and underground is an important factor as it is used not only for drinking purpose, domestic uses and other uses like agriculture. In health hazards if the quality of water is not confirming to the prescribed standards. To assess the impact of the various operations that were undertaken by the ONGC, certain analytical tests were carried out at the identified water sources from the villages located in Andhra Pradesh and Assam.

In order to study the impact of oil drilling on the water component of the ecosystem, water samples were collected and analysed for thirty different parameters so as to obtain a holistic picture of the water quality in its present state at the activity sites. The selected parameters were studied under the following sections, water analysis was carried out in the category of Physical parameters, Chemical parameters (inorganic, organic, heavy metals), Cummulative parameters, and Biological parameters.

Physical parameters:

Temperature, Turbidity, Total Dissolved Solids, Total Suspended Solids

Chemical parameters:

Inorganic

PH, Electrical Conductivity (E.C), Alkalinity, Total Hardness, Magnesium – hardness, Calcium-hardness, Fluorides, Sulphates, Chlorides.

organic

nitrates, Phosphates, Potassium, Phenol, Oil and grease,

Heavy metal

Lead, Manganese, Chromium, Zinc, Iron, Nickel, Cadmium and Copper.

Cumulative parameters

Dissolved Oxygen (D.O), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD).

Biological parameters

Most Probable Number (MPN)

Wastewater samples from drill site and water samples were collected from different sources such as surface water, open well, and borewells. The data are presented in tables from 4.1 and 4.2

Table 4.1: Analytical results of waste water from a drilsite waste pit, Kesanapalli

S.No	PARAMETER	VALUE
1	PH	8
2	TEMPERATURE deg C	27.5
3	CONDUCTIVITY mS	1.6
4	TURBIDITY (NTU)	890
5	TDS (PPM)	6608
6	TSS (PPM)	1900
7	ALKALINITY (PPM)	800
8	TOTAL HARDNESS (PPM)	160
9	CALCIUM HARDNESS (PPM)	32
10	CHLORIDE (PPM)	70
11	SULPHATE (PPM)	10
12	FLUORIDE (PPM)	0.8
13	SODIUM (PPM)	525
14	POTASSIUM (PPM)	4.8
15	SILICATE (PPM)	45
16	PHOSPHATE (PPM)	0.67
17	NITRATE (PPM)	2480
18	PHENOL (PPM)	0.24
19	D.O (PPM)	BDL
20	BOD (PPM)	120
21	COD (PPM)	540
22	OIL AND GREASE (PPM)	8
23	ZINC (PPB)	180
24	LEAD (PPB)	BDL
25	BARIUM (PPB)	1156
26	MANGANESE (PPB)	489
27	IRON (PPB)	11301
28	CHROMIUM (PPB)	3209
29	COPPER (PPB)	BDL
30	CADMIUM (PPB)	BDL

Waste water at the selected site was collected and analyzed for various parameters to assess the quality of waste generated by the drilling and other activities. The results of the study are described as below.

PH was found to be alkaline (8.0). EC was found to be at 1.6mS/cm indicating higher amount of dissolved solids. Higher turbidity values of 890 NTU indicated high amounts of suspended solids (1900 mg/ L). The Dissolved solids showed very high values of 6608 ppm. Similarly higher values of alkallinity (800mg/L) indicate the basic characteristic of the wastewater. Nitrates showed dangerously high values of 2480 mg/L, indicating a potential pollution source, if not treated before disposing it off to natural waters. Low values of DO (BDL), and high values of BOD (120 mg/L) and COD (540 mg/L) are indicative of the chemical content of the wastewater. Oil and Grease values showed 8 mg/L. Heavy metals such as Zinc (180 ppm), Barium (1156 ppm), Manganese (489 ppm) indicates a need for treatment before letting the water into natural water bodies.

Very high values were noticed for both Iron (11301 mg/L) and Chromium (3209) that are toxic at such concentration. Lead, copper and Cadmium were BDL. Fluoride concentrations appear to be normal at 0.8 mg/L. high levels of silicates at 45 ppm were noticed and can be attributed to drilling activities. It was found that all these *parameters* are with in the CPCB guidelines.

This discharged water contains a small quantity of greases and oil deposits. This waste water can enter the local streams of water bodies and have an effect on the acqua culture, flora and fauna, and other irrigated lands, as well as the coconut grives in the neighborhood. Table 4.3 provides an chemical analysis of this waste water based upon the grease and oil content on different samples collected from different locations like – surge pond inlet, bottom of the surge pound, calarifier outlet etc. It also measures the amount of oil and grase mg/L of water. Since the contamination is a function of rate of flow, seasonally, and gradient, the amount of discharged water has to be checked more frequently.

Table.4.2: oil & Grease estimation of water samples from different units of a typical effluent treatment plant

Sl. No.	Location of Sampling	Data recorded at the time of sampling	Oil and Grease content, mg/l
1	Surge pond inlet		5.7
2	Surge pond I (bottom)	Volume of water = $3500m^3$	1.73
3	Post-API Separator	Rate of Flow =$50m^3$ / hr	2.14
4	Clarifier- outlet	Rate of flow = $50m^3$ / hr Temperature = 34^0 C	0.01
5	Guard Pond II (Settled condition)	Volume of water = 1000 m^3 Temperature = 30.5^0 C	0.01
6	Final disposal	Temperature = 32.5^0 C	0.015

From the analytical data, it becomes apparent that proper care should be taken before releasing such wastewater into natural bodies, for instance treatment to remove / reduce the quantum of various pollutants. In view of the potential of pollution from the wastewater generated from various drilling activities, ONGC has constructed treatment plants to treat the effluents. The status and disposal means of the effluent treatment plants are given in the following tables (tables 4.3 and 4.4)

Table 4.3: Functional Status of Effluent Treatment Plant at drilling sites (Andhra Pradesh)

Name of the Village	Treatment Plant	Degree of Treatment and disposal method
Kesanapalli	Available	Treated and let into a nearby canal
Karavaka	Available	Part of the water is recycled
Ethakota	Available	Treated and partly recycled

Table 4.4: Functional Status of Effluent Treatment Plant at drilling sites (Assam)

Name of the Village	Treatment Plant	Degree of Treatment and disposal method
Konwarpur	Available	Treated and let into a river
Hatipati	Available	Treated and directed to a nearby barren land

The above tables indicate that proper treatment facilities are available in the sampled villages. Sometimes the water is recycled before releasing into the open areas. In order to quantify the pollution load emanating from the drilling activities and to study the impact of released effluents on the water resources at micro-level, samples from three different predominant in the study area: Surface water, Open wells and Borewells. The Table 4.5 illustrates the results. Overall the results indicate that surface waters near the drill site has no significant impact at post drilling stage.

Impact of Drilling Activities on Surface Water

On account of their geographical features, surface water bodies are most susceptible to the anthrapogenic polluting sources. The results of the study conducted on various pollution parameters are given below.

Temperature plays a very important role in an aquatic system as it affects the chemical and biological properties such as solubility of oxygen, carbonate-bicarbonate equilibrium, increase in metabolic rate and affects the physiological reactions of organisms, etc. Water temperature is important in relation to fish life. The average ranged from 29.5^0 C during pre-drilling to 27.7^0 C during the drilling stages. Turbidity, an expression of optical property water, wherein light is scattered by suspended particles present (Tyndall effect). Higher values of turbidity represent proportional decrease of ecosystem productivity.

Turbidity showed values of 33.0 NTU during pre-drilling stages to 64.2 NTU during drilling stages. Dissolved solids, the portion of solids that are in dissolved state in solution. Higher TDS was noticed during the drilling time (345.0 mg/L) as compared to the pre-drilling stage (162.0 mg/L). However, lower values of TSS was noticed, 9.6 mg/L during pre-drilling stage to about 30.6 mg/L during the drilling stages. Thus, there was an impact of ONGC operations on the quality of the surface water sources in terms of the Turbidity, TDS, TSS.

Table 4.5: Analytical Results of surface water near a drillsite, Kesanapalli

Parameter	Pre drilling	Drilling	Post drilling
PH	6.4	8.0	NS
TEMPERATURE deg C	29.5	27.7	NS
CONDUCTIVITY mS	0.5	0.2	NS
TURBIDITY (NTU)	64.2	33.0	NS
TDS (PPM)	345.0	162.0	NS
TSS (PPM)	30.6	29.6	NS
ALKALINITY (PPM)	260.0	120.0	NS
TOTAL HARDNESS (PPM)	260.0	100.0	NS
CALCIUM HARDNESS (PPM)	56.0	24.0	NS
CHLORIDE (PPM)	40.0	50.0	NS
SULPHATE (PPM)	18.3	5.9	NS
FLUORIDE (PPM)	BDL	BDL	NS
SODIUM (PPM)	25.4	41.8	NS
POTASSIUM (PPM)	4.3	2.0	NS
SILICATE (PPM)	28.0	16.0	NS

Parameter	Pre drilling	Drilling	Post drilling
PHOSPHATE (PPM)	0.8	0.1	NS
NITRATE (PPM)	27.2	41.8	NS
PHENOL (PPM)	BDL	BDL	NS
D.O (PPM)	2.4	5.2	NS
BOD (PPM)	7.3	6.9	NS
COD (PPM)	13.3	13.6	NS
OIL AND GREASE (PPM)	0.004	BDL	NS
ZINC (PPB)	287.0	BDL	NS
LEAD (PPB)	BDL	BDL	NS
BARIUM (PPB)	19.0	35.0	NS
MANGANESE (PPB)	846.0	92.0	NS
IRON (PPB)	14.0	36.0	NS
CHROMIUM (PPB)	BDL	BDL	NS
COPPER (PPB)	BDL	BDL	NS
CADMIUM (PPB)	BDL	BDL	NS

pH effects the chemical and biological properties of water. Natural waters pH is governed by the carbon dioxide/ bicarbonate/ carbonate equilibria and ranges between 4.5 and 8.5 although mostly basic. pH of the water at the site before drilling showed acidic (6.4) condition and registered higher values during the drilling operation (8.0). Electrical Conductivity, which is a measure of the ionic properties of the water body, showed values of 0.5 mS/ cm during drilling operation as compared to the pre-drilling stages 0.2 mS/ cm. Total Hardness, predominantly caused by divalent cations such as Calcium, Magnesium, and others is the sum of total cations present in the water. The values ranged from 100.0 mg/L during pre-drilling stage to 280.0 mg/L during the drilling stages, which is perhaps due to the drilling activities. As calcium hardness itself does not show the similar rise during operations, it showed an average of 24.0 mg/L during the pre-drilling stages to 54.0 mg/L during operation. The concentration of sodium in water is of prime concern when considering their solubility for agricultural uses. Its concentration in water ranged from a low of 25.4 mg/L, pre-drilling to 41.8 mg/L drilling. Fluorides have dual significance in water supplies. Higher concentration causes 'Dental Flourisis' and lower concentrations (<0.8 mg/L) in drinking waters causes 'Dental Caries'. Fluorides was found at be below detectable levels during both pre-drilling and drilling periods. Sulphates are found appreciably in all natural waters. Sulphates showed lower values, from 5.9 mg/L (pre-drilling) to 18.3 mg/L, during drilling operation. Chlorides in natural waters are present mainly due to dissolution of salt deposits in the form of ions (Cl^-). It is the major form of inorganic anions in water for aquatic life. It averaged at 40 mg/L during stage to 50.0 mg/L during drilling operation. Total alkalinity showed values of 120 mg/L during to pre-drilling stage to 240.0 mg/L during the drilling activity. Oil and grease very found to be extremely low indicating negligible impact of the drilling operation on the water quality.

Nitrates are the highest oxidized form of nitrogen unpolluted natural waters contain only minute quantities of nitrates but results indicate high values of nitrates during both pre-drilling and drilling stages is perhaps due to the geological character of the area. Phosphates occur in natural waters or waste waters as phosphates. Phosphates are essential to the growth of organism and can be a nutrient that limits the primary productivity of the water productivity of the water body. It showed very low values during both pre and drilling operation (0.8 to 0.1 mg/L). It values very low averaging 2.0 during pre-drilling to 4.3 mg/L during drilling.

Oxygen dissolved in water is a very important parameter in water analysis as it serves as an index of the physical, chemical and biological activities. The two main sources of dissolved oxygen, are: Diffusion of oxygen from the air and Photosynthetic activity. It is considered to be a primary limiting factor in water loaded with organic materials in the process of self-purification. The DO averaged 2.4 mg/L during the pre-drilling stage to 5.0 mg/L during the drilling stage. Biological Oxygen Demand (BOD), defined as the amount of Oxygen required by the microorganisms while stabilizing biologically decomposable Organic matter (Carbonaceous), in waste water under aerobic conditions. It is a critical parameter, which indicates the health status of the water. The values ranged from 6.9 mg/L to 7.3 mg/L, indicating introduction of organic compounds into the water during the drilling activities. The chemical oxygen demand (COD), defined as the measure of Oxygen equivalent to the organic matter content of the sample that is susceptible to oxidation by a strong chemical oxidant. The values were found to be 13.3 and 13.6 mg/L respectively during the pre and drilling stages.

Lead is relatively minor element in the earth's crust is widely distributed in low concentrations in uncontaminated soils and rocks. Lead concentrations were found to be below detectable level. Copper again was found BDL. Iron is abundant element in the earth's crust, but exists generally in minor concentrations in natural water systems. Iron is found in the +2 and +3 states depending on the oxidation-reduction potentials of the water. Iron was found to be 14 ppb during pre-drilling stages to 35.0 ppd. Chromium, Copper, Lead, and Cadmium concentrations were found to be 'below detectable level'.

Table. 4.6: Analytical Results of open well water near a drill site, Kesanapalli.

Parameter	Pre drilling	Drilling	Post drilling
PH	7.0	7.5	7.4
TEMPERATURE deg C	28.7	27.7	32.5
CONDUCTIVITY mS	1.7	1.8	2.3
TURBIDITY (NTU)	4.6	2.5	2.2
TDS (PPM)	1199.0	1168.0	1542.3
TSS (PPM)	3.6	2.1	3.9
ALKALINITY (PPM)	507.5	480.0	417.5
TOTAL HARDNESS (PPM)	530.5	532.5	640.0
CALCIUM HARDNESS (PPM)	116.3	126.0	142.0
CHLORIDE (PPM)	256.3	337.5	333.0
SULPHATE (PPM)	58.6	60.5	57.8
FLUORIDE (PPM)	0.6	0.6	0.6
SODIUM (PPM)	145.7	115.9	166.8
POTASSIUM (PPM)	55.2	25.8	28.3
SILICATE (PPM)	41.9	41.5	34.7
PHOSPHATE (PPM)	1.5	0.7	1.1
NITRATE (PPM)	70.3	65.9	59.9
PHENOL (PPM)	BDL	BDL	BDL
D.O (PPM)	2.8	2.6	2.8
BOD (PPM)	3.4	3.9	4.0
COD (PPM)	6.9	6.7	7.8
OIL AND GREASE (PPM)	0.004	0.007	0.006
ZINC (PPB)	33.0	BDL	BDL
LEAD (PPB)	BDL	BDL	BDL
BARIUM (PPB)	17.3	11.0	17.0
MANGANESE (PPB)	663.3	487.0	484.8
IRON (PPB)	88.3	72.8	45.3
CHROMIUM (PPB)	11.0	BDL	9.0
COPPER (PPB)	39.0	8.0	BDL
CADMIUM (PPB)	BDL	BDL	BDL

Impact of Drilling Activities on Open Well:

Open wells are, in view of embankments and other protective measures are less susceptible to surface pollution as compared to the surface water. However, the water quality of open well often depends on the surface of water i.e. the quality of aquifer that feeds the water to open well. Drilling activities often causes changes in the quality of aquifers. As the study area is from deltaic area of Godavari river, the level of ground water table is high and most of the drilling activities are conducted much below the ground water table. The quality of open well in relation to various parameters analyzed is given below.

Temperature, of the water averaged 32.2^{0}C during post-drilling and 27.7^{0}C during drilling stages. Turbidity, showed very low values ranging from 2.2 NTU to 4.6 NTU during various stages. Dissolved solids showed very high values of 1199 mg/L, 1168 mg/L and 1542 mg/L during pre, drilling and post drilling operation respectively.

pH was found to be in the neutral to slight alkaline range (7.0 to 7.5). Conductivity was found to be higher at 2.3 mS/cm during post-drilling operation owing to various physical and chemical treatment involved during the operation. Hardness is predominantly caused by divalent cations such as Clacium, magnesium, alkaline earth metal contains as iorn, maganese, strontium etc. Higher hardness values were found in open wells with values averaging 530.5 mg/L (pre-drilling), 532.5 mg/L (drilling) and 640.0 mg/L (post drilling) activity. The presence of calcium in water results from passage through or over deposits of limestone, dolomite, gypsum and such other calcium bearing rocks. It averaged 116.3, 126.0 and 142.0 mg/L during pre, drilling and post drilling respectively.

Nitrates, were found in high range with values from 60 to 70 mg/L. such high concentrations cause ‘eutrophication’ in water bodies and ‘Blue baby syndrome’ in children. Phosphates are essential to the growth of organisms and acts as a nutrient that limits the primary productivity of the water body. Inorganic phosphorus plays a dynamic role in aquatic ecosystems though present in low concentration, it is one of the most important nutrients. When present in excess along with nitrates and potassium causes algal blooms. It values were low. Potassium though found in small quantities (<20 mg/l) plays a vital role in the metabolism of fresh water environment. It ranged from 28.0 mg/L to 55.0 mg/L.

Dissolved Oxygen, a critical parameter showed lower values of 2.6, 2.8 and 2.8 mg/L during various stages of oil exploration. Diffusion of oxygen from the air into the water depends on the solubility of oxygen, and is influenced by host of other factors such as water movements, temperature, salinity, etc. Both BOD and COD were found to be very low. Sodium, one of the most abundant elements is a common constituent of natural waters showed values of 145 and 156 mg/L during pre and post drilling operation respectively. Fluorides was found to be 0.6 mg/L during the entire operation. Chloride showed values ranging from 256.0 during pre-drilling to 333.0 mg/L during post-drilling operation. Except manganese (whose values ranged from 487 – 663 ppb), Copper (8.0 and 39.0 ppb), Iron (88.3 ppb-pre, 72.8 drilling and 45.3 post drilling) other heavy metals were either in the BDL or at insignificant level.

Impact of Drilling Activities on Borewell

Bore wells, due to their sources and structure are least susceptible to pollution unlike the surface water. However, any subsurface activities like drilling etc may cause changes in the water quality of aquifers drastically. Details of various parameters are given in Table 4.7.

Temperature, of the ground water samples showed values ranging from 32.3 ^{0} C during post-drilling to 27.8 ^{0} C during drilling stages. Dissolved Solids showed values ranging from 1200 mg/L to 509 mg/L during the post-drilling sampling. Lower turbidity, values were noticed with values ranging from 12.3 to 15.7 NTU.

The pH was found to be in mostly neutral during all times and the EC ranged from 0.9 – 1.9 mS/ cm. The alkalinity values ranged from 370 – 493.3 ppm and hardness from 330.0 to 547 mg/L. Calcium values averaged between 78.0 mg/L to 90.0 mg/L. Phosphates values ranged from 0.4 to 1.1 mg/L. Nitrates were found in excess with values ranging from 49.3 to 58.2 mg/L causing potential concern on human health in the area. Potassium values were higher ranging from 34 to 60 mg/L, it could be attributed to the geology of the area, while silicates showed values ranging from 30 mg/L to 38 mg/L.

Phenol was found to be BDL during all stages of the activity. DO was again found to be low with values ranging from 2.0 to 2.8 mg/L. Both BOD and COD were found to be very low with values ranging from 1.5 – 3.0 mg/L and 4.0 to 7.6 respectively. Values for Sodium showed values ranging from 46 to 125 mg/L while fluorides values were found to be 0.6 mg/L. The values for chlorides ranged from 80.0 mg/L to 347 mg/L. Chromium values showed 11pb, while higher values of manganese were noticed (346 – 717 ppb). Iron was found to range from 22 ppb to 54 ppb while cadmium were found to be BDL.

Table. 4.7: Analytical Results of Bore well water near a drill site, Kesanapalli.

Parameter	Pre drilling	Drilling	Post drilling
pH	7.2	7.5	7.4
TEMPERATURE deg C	28.9	27.8	32.3
CONDUCTIVITY mS	1.3	1.9	0.9
TURBIDITY (NTU)	12.3	13.2	15.7
TDS (PPM)	882.8	1200.3	509.0
TSS (PPM)	10.8	4.5	7.0
ALKALINITY (PPM)	402.5	493.3	370.0
TOTAL HARDNESS (PPM)	447.5	546.7	330.0
CALCIUM HARDNESS (PPM)	90.0	96.0	78.0
CHLORIDE (PPM)	208.8	346.7	80.0
SULPHATE (PPM)	102.3	136.4	39.5
FLUORIDE (PPM)	0.5	0.6	0.6
SODIUM (PPM)	100.6	125.7	46.5
POTASSIUM (PPM)	59.7	54.4	3.4
SILICATE (PPM)	33.5	37.3	29.9
PHOSPHATE (PPM)	1.1	0.4	0.6
NITRATE (PPM)	53.9	58.2	49.3
PHENOL (PPM)	BDL	BDL	BDL
D.O (PPM)	2.6	1.9	2.8
BOD (PPM)	1.9	3.1	1.5
COD (PPM)	5.0	7.6	4.0
OIL AND GREASE (PPM)	0.004	0.004	0.005
ZINC (PPB)	184.0	154.0	85.0
LEAD (PPB)	BDL	BDL	BDL
BARIUM (PPB)	15.5	12.0	7.0
MANGANESE (PPB)	630.3	717.7	346.0
IRON (PPB)	53.3	39.3	22.0
CHROMIUM (PPB)	11.0	10.0	10.0
COPPER (PPB)	13.0	8.0	BDL
CADMIUM (PPB)	BDL	BDL	BDL

Comparison of water quality from various sources

To study the impact of drilling activities on different sources of water, a comparison was made between three different sources – surface water, open well and borewell. The data is given the following tables. To compare the quality of water overtime, data from three different phases of ONGC activities were collected to represent the Pre-Drilling, Drilling and Post-Drilling phases.

Water Quality during Pre-Drilling Stage:

Study of the water samples during pre-drilling stage showed that the water was found to be clear through out the study period (Table 4.8).

Table. 4.8: Comparison of Water Quality from Different Sources (Pre-Drilling Phase), Kesavanpalli

Parameter	Open Well	Surface Water	Bore Well
pH	7.0	6.4	7.2
TEMPERATURE deg C	28.7	29.5	28.9
CONDUCTIVITY mS	1.7	0.5	1.3
TURBIDITY (NTU)	4.6	64.2	12.3
TDS (PPM)	1199.0	345.0	882.8
TSS (PPM)	3.6	30.6	10.8
ALKALINITY (PPM)	507.5	260.0	402.5
TOTAL HARDNESS (PPM)	530.5	260.0	447.5
CALCIUM HARDNESS (PPM)	116.3	56.0	90.0
CHLORIDE (PPM)	256.3	40.0	208.8
SULPHATE (PPM)	58.6	18.3	102.3
FLUORIDE (PPM)	0.6	BDL	0.5
SODIUM (PPM)	145.7	25.4	100.6
POTASSIUM (PPM)	55.2	4.3	59.7
SILICATE (PPM)	41.9	28.0	33.5
PHOSPHATE (PPM)	1.5	0.8	1.1
NITRATE (PPM)	70.3	27.2	53.9
PHENOL (PPM)	BDL	BDL	BDL
D.O (PPM)	2.8	2.4	2.6
BOD (PPM)	3.4	7.3	1.9
COD (PPM)	6.9	13.3	5.0
OIL AND GREASE (PPM)	0.004	0.004	0.004
ZINC (PPB)	33.0	287.0	184.0
LEAD (PPB)	BDL	BDL	BDL
BARIUM (PPB)	17.3	19.0	15.5
MANGANESE (PPB)	663.3	846.0	630.3
IRON (PPB)	88.3	14.0	53.3
CHROMIUM (PPB)	11.0	BDL	11.0
COPPER (PPB)	39.0	BDL	13.0
CADMIUM (PPB)	BDL	BDL	BDL

The pH was noticed to be close to neutral. The water temperature ranged from about 28.7 – 29.5 ^{0} C and conductivity showed to range from 0.5 mS/cm to 1.7 mS/cm. Low turbidity values were noticed at 4.6 NTU in open well water and 46.2 NTU in surface waters. The suspended solids during the study period ranged from 260 –

508 ppm to 260 – 530 mg/L respectively. Silicates ranged from 28 ppm in surface waters to 42 ppm in open waters.

High values of nitreates were noticed with values ranging from 27 ppm in surface waters to 70.3 ppm in open waters. The important parameters that determine the quality of water are D.O BOD and COD. The DO values averaged 2.8, 2.4, and 2 mg/L in open, surface and bore well waters respectively. Low values of BOD and COD were noticed for all the sample classes.

Except few parameters like manganese, which showed higher values, copper showed values of 39.0 ppb in open well waters, zinc, 287 ppb in surface waters and 184 ppb in borewell waters while the other heavy metals were found to be at below detectable levels. Thus, the water quality of all the three sources do not show any characteristic pollution, with exception of natural sources of contamination like suspended solids and ions.

Water Quality Drilling Phase:

Comparative assessments of different sources of water during the drilling stages were done with the drinking water standards (table 4.9). The pH of all the sources (open well, surface water and borewells) was found to be in neutral-alkaline range. High EC was noticed in both open and borewell waters at, 1.8 and 1.9 mS/cm respectively which can be attributed to higher dissolved solids. However, the dissolved solids showed a significant variation from 162.0 ppm in surface water to 1200 ppm in borewell samples during pre drilling activity which is due to higher dissolved salts. Alkalinity values were found to be higher, ranging from 120 – 494 ppm in borewell water. Hardness in both open wells and borewells were found to be higher at 532 and 547 ppm respectively. Potassium was found to be higher with values ranging from 25.8 ppm in open water and borewell 54.4 ppm.

Tablr 4.9: Comparison of Water Quality from Various sources during Drilling Phase, Kesavanpalli

Parameter	Open Well	Surface Water	Bore Well
pH	7.5	8.0	7.5
TEMPERATURE deg C	27.7	27.7	27.8
CONDUCTIVITY mS	1.8	0.2	1.9
TURBIDITY (NTU)	2.5	33.0	13.2
TDS (PPM)	1168.0	162.0	1200.3
TSS (PPM)	2.1	29.6	4.5
ALKALINITY (PPM)	480.0	120.0	493.3
TOTAL HARDNESS (PPM)	532.5	100.0	546.7
CALCIUM HARDNESS (PPM)	126.0	24.0	96.0
CHLORIDE (PPM)	337.5	50.0	346.7
SULPHATE (PPM)	60.5	5.9	136.4
FLUORIDE (PPM)	0.6	BDL	0.6
SODIUM (PPM)	115.9	41.8	125.7
POTASSIUM (PPM)	25.8	2.0	54.4
SILICATE (PPM)	41.5	16.0	37.3
PHOSPHATE (PPM)	0.7	0.1	0.4
NITRATE (PPM)	65.9	41.8	58.2
PHENOL (PPM)	BDL	BDL	BDL
D.O (PPM)	2.6	5.2	1.9
BOD (PPM)	3.9	6.9	3.1
COD (PPM)	6.7	13.6	7.6
OIL AND GREASE (PPM)	0.007	BDL	0.004
ZINC (PPB)	BDL	BDL	154.0
LEAD (PPB)	BDL	BDL	BDL
BARIUM (PPB)	11.0	35.0	12.0
MANGANESE (PPB)	487.0	92.0	717.7
IRON (PPB)	72.8	36.0	39.3
CHROMIUM (PPB)	BDL	BDL	10.0
COPPER (PPB)	8.0	BDL	8.0
CADMIUM (PPB)	BDL	BDL	BDL

High values of nitrates were noticed in all the water sources with values ranging from 42 – 66 ppm, causing serious concern. Low values were noticed for all the critical parameters, namely DO, BOD and COD. Except for copper, iron and manganese, most of the heavy metals analyzed showed values BDL.

Water Quality during Post- Drilling Phase

Water quality of four open wells in the proximity of the drill site and two bore well water were analysed for water contamination. The results are as discussed here (table 4.10).

Table 4.10: Comparison of water quality from different sources during Post Drilling Phase, Kesavanpalli

Parameter	Open Well	Surface Water	Bore Well
pH	7.4	NS	7.4
TEMPERATURE deg C	32.5	NS	32.3
CONDUCTIVITY mS	2.3	NS	0.9
TURBIDITY (NTU)	2.2	NS	15.7
TDS (PPM)	1542.3	NS	509.0
TSS (PPM)	3.9	NS	7.0
ALKALINITY (PPM)	417.5	NS	370.0
TOTAL HARDNESS (PPM)	640.0	NS	330.0
CALCIUM HARDNESS (PPM)	142.0	NS	78.0
CHLORIDE (PPM)	333.0	NS	80.0
SULPHATE (PPM)	57.8	NS	39.5
FLUORIDE (PPM)	0.6	NS	0.6
SODIUM (PPM)	166.8	NS	46.5
POTASSIUM (PPM)	28.3	NS	3.4
SILICATE (PPM)	34.7	NS	29.9
PHOSPHATE (PPM)	1.1	NS	0.6
NITRATE (PPM)	59.9	NS	49.3
PHENOL (PPM)	BDL	NS	BDL
D.O (PPM)	2.8	NS	2.8
BOD (PPM)	4.0	NS	1.5
COD (PPM)	7.8	NS	4.0
OIL AND GREASE (PPM)	0.006	NS	0.005
ZINC (PPB)	BDL	NS	85.0
LEAD (PPB)	BDL	NS	BDL
BARIUM (PPB)	17.0	NS	7.0
MANGANESE (PPB)	484.8	NS	346.0
IRON (PPB)	45.3	NS	22.0
CHROMIUM (PPB)	9.0	NS	10.0
COPPER (PPB)	BDL	NS	BDL
CADMIUM (PPB)	BDL	NS	BDL

The pH values were observed within the limits of potable water standards. EC ranged from 0.9 mS/cm to 2.3 mS/cm. The alkalinity at open well during post-drilling activity was found to be 417 ppm and 370 ppm in the bore well samples. Chloride, Sodium and Potassium levels in the water changed drastically from 333 to 80 ppm, 167 to 47 ppm and 28.3 to 3.4 ppm in open well and ground waters respectively. Higher values of hardness were noticed with values ranging from 640 ppm to 330 ppm.

The average values of DO remained from the same at both open well and bore well waters, while BOD reduced from 4.0 to 1.5 COD was found to be very low. Very high values of nitrates were noticed ranging from about 60 ppm to 50 ppm in open well and bore well waters respectively. Except for manganese, chromium and iron most of the haevy metals analysed were found to be BDL. The fluoride concentrations remained the same (0.6 ppm) at both open and bore wells and well with in the limits. Oil and grease level in ground water samples were insignificant at 0.006 ppm to 0.005 ppm during post-drilling phase.

Water samples were analysed for the various physico-chemical parameters at different villages to assess the water quality. The result of the water analysis (inorganic parameters) near the drill site are presented in Table 4.11 while the nutrient and organic paraemters are discussed in Table 4.12. The physical parameters near the drill are given in Table 13. The pH of water in all the villages studied were mostly in the neutral rnage while high EC noticed especially in villages located in Assam which could be due to the geology of the regoin. Similarly alkalinity during the pre-drilling stages were high in Assam villages ranging from 540 – 780 ppm while hardness ranged from 780- 1200 ppm from pre to post drilling stage. Chlorides were noticed to be higher in Hatipati (Assam) where values ranged from 620 – 960 ppm. Low values of sulpahtes were noticed in all the villages. Higher values of sodium and potassium were noticed at Assam, which could be attributed to the geological composition of the region. Very high values for nitrate were noticed in all the study sites with most samples showing values > 40ppm, that could cause serious human health hazards and eutropication in natural waterbodies.

TDS were again found to be very high in Hatipati (2272 –pre drilling, 3751 ppm post drilling) in Assam.

Table 4.11 Water analysis – Inorganic parameters near a drill site (results expressed in ppm)

Water analysis – Physical parameter near a drill site.

Village Name	pH			Temp in Celsius			Conductivity mS		
	PD	D	POST	PD	D	POST	PD	D	POST
Kesanapaali	6.9	7.5	7.3	29.1	27.5	32.4	1.37	1.26	1.21
Karavaka	6.4	8.0	NS	29.5	27.7	NS	0.54	0.24	NS
Ethakota	7.5	NS	7.2	29.2	NS	32.2	0.28	NS	1.10
Konwarpur	7.0	7.5	NS	29.0	27.4	NS	2.71	2.97	NS
Hatipati	6.9	7.4	7.1	28.7	27.6	32.6	2.73	3.50	4.96

Village Name	ALKALINITY			TOTAL HARDNESS			Ca HARDNESS			CHLORIDE		
	PD	D	POST	PD	D	POST	PD	D	POST	PD	D	POST
Kesanapaali	620	540	360	552	460	480	117	80	112	110	100	30
Karavaka	260	120	NS	260	100	NS	56	24	NS	40	50	NS
Ethakota	140	NS	460	110	NS	400	28	NS	92	25	NS	60
Konwarpur	780	740	NS	890	740	NS	176	120	NS	470	550	NS
Hatipati	540	580	410	780	860	1200	164	224	256	620	900	960

Village Name	SULPHATE			FLUORIDE			SODIUM			POTASSIUM		
	PD	D	POST	PD	D	POST	PD	D	POST	PD	D	POST
Kesanapaali	39.5	35.2	38.7	0.4	0.3	0.4	104.0	68.3	67.0	10.0	4.0	5.6
Karavaka	18.3	5.9	NS	0.7	0.4	NS	25.4	41.8	NS	4.3	2.0	NS
Ethakota	11.1	NS	20.4	0.5	NS	0.4	15.8	NS	40.0	6.6	NS	4.9
Konwarpur	60.7	56.6	NS	0.6	0.5	NS	219.0	153.0	NS	153.0	129.0	NS
Hatipati	97.6	151.6	138.0	0.9	0.8	0.8	300.0	270.0	442.0	84.6	43.8	54.5

Table 4.12: Water analysis – Nutrient and Oganic parameters near a drill site (in PPM)

Village Name	SILICATE			PHOSPHATE			NITRATE		
	PD	D	POST	PD	D	POST	PD	D	POST
Kesanapaali	38.0	35.0	31.0	0.9	0.5	0.4	70.5	68.3	80.0
Karavaka	28.0	16.0	NS	0.8	0.5	NS	27.2	41.8	NS
Ethakota	18.2	NS	25.2	1.1	NS	0.5	46.8	NS	52.2
Konwarpur	35.5	37.5	NS	1.3	0.4	NS	70.4	50.0	NS
Hatipati	41.4	42.5	37.7	1.2	0.6	1.5	76.2	70.9	62.6

Table 4.13: Water analysis – Physical parameters near a drill site (in PPM)

Village Name	TURBIDITY (NTU)			TDS (PPM)			TSS (PPM)		
	PD	D	POST	PD	D	POST	PD	D	POST
Kesanapaali	5.0	2.1	2.5	864	772	730	2.4	1.6	2.0
Karavaka	64.2	33.0	NS	345	162	NS	30.6	29.6	NS
Ethakota	16.5	NS	14.2	204	NS	622	16.4	NS	8.0
Konwarpur	18.2	14.8	NS	1656	1834	NS	17.6	7.6	NS
Hatipati	1.6	1.0	1.4	2272	2274	3571	3.6	1.6	4.8

Table 4.13a: Nutrient and Organic parameter near a drill site (in PPM)

Village Name	DO			BOD			COD			OIL & GREASE		
	PD	D	POST	PD	D	POST	PD	D	POST	PD	D	POST
Kesanapaali	2.2	2.2	2.8	2.3	3.2	2.6	4.9	6.8	4.8	BDL	BDL	0.004
Karavaka	2.4	5.2	NS	7.3	6.9	NS	13.3	13.6	NS	0.008	0.01	NS
Ethakota	4.8	NS	3.2	1.4	NS	1.2	2.8	NS	4.8	0.003	BDL	BDL
Konwarpur	2.6	2.0	NS	2.1	3.0	NS	7.0	10.4	NS	BDL	0.004	0.004
Hatipati	2.2	1.8	2.4	7.4	6.4	6.7	14.9	8.4	10.0	0.003	0.008	0.006

Heavy metals near a drill site (in ppb)

Village Name	ZINC			LEAD			BARIUM			MANGANESE		
	PD	D	POST	PD	D	POST	PD	D	POST	PD	D	POST
Kesanapaali	33.0	BDL	BDL	BDL	BDL	BDL	11.0	6.0	BDL	1130	495	597
Karavaka	287.0	BDL	NS	BDL	BDL	NS	19.0	35.0	NS	846	92	NS
Ethakota	BDL	NS	BDL	BDL	NS	BDL	26.0	NS	7.0	54	NS	59
Konwarpur	243.0	BDL	NS	BDL	BDL	NS	16.0	18.0	NS	909	833	NS
Hatipati	BDL	BDL	BDL	BDL	BDL	BDL	13.0	10.0	BDL	458	764	683

Heavy metals near a drill site (in ppb)

Village Name	IRON			CHROMIUM			COPPER			CADMIUM		
	PD	D	POST	PD	D	POST	PD	D	POST	PD	D	POST
Kesanapaali	236.0	187.0	64.0	BDL	BDL	BDL	39.0	BDL	BDL	BDL	BDL	BDL
Karavaka	14.0	36.0	NS	BDL	BDL	NS	BDL	BDL	NS	BDL	BDL	NS
Ethakota	61.0	NS	23.0	BDL	NS	10.0	BDL	NS	BDL	BDL	NS	BDL
Konwarpur	101.0	12.0	NS	11.0	BDL	NS	13.0	BDL	NS	BDL	BDL	NS
Hatipati	28.0	32.0	25.0	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

The critical parameters of DO showed low values, although BOD and COD were not of any serious concern in all the study sites. The DO values ranged from 1.8 – 4.8, although for an healthy water quality 5 ppm is recommended.

Among the heavy metals, Manganese showed high values at Kesanapalli, Konwapur and Hatipati raning from 458 to 1130 ppb, and iron showed higher values in Kesanapalli ranging from 64 – 236 ppb, while most the other metals showed values below detectable level.

Air Quality

Air quality is one of the basic indicators in determining the impact on a particular environment on account of any activity. The primary sources of emissions from oil and gas exploration operations to air are:

- Flaring, venting and purging gases, including black smoke emissions
- Combustion processes, such as diesel engines
- Fire protection systems
- Road traffic
- Fugitive gas losses

Principal gaseous emissions from oil and gas operations may include carbon dioxide, carbon monoxide, methane, volatile organic carbons (voc), nitrogen oxides and halons.

Emissions of sulphur dioxide and hydrogen sulphide can occur and will depend on the sulhur content of natural gas and diesel, particularly when used as a power source. In some cases, flaring and combustion can lead to odour production, and special consideration should be given to the siting of flares and / or the treatment of waste gases.

Drilling operations are temporary phenomena and typically last about three months (the duration however, depends on a number of factors such as depth of well, complications encountered during drilling etc). the emissions pose potential hazards to human health and environment of the drilling site and therefore there is a need for effective monitoring and timely action both by the drilling authority and the regulatory agencies to prevent any adverse effect the environment. In India, CPCB has set National Ambient Air Quality Standards (NAAQS) for three different categories namely Industrial, Domestic and Sensitive areas and accordingly, the emission levels need to comply with these standards. Table – 4.14 shows the set of standards for some of the major air pollutants. In order to study the air environment a study was carried out at the drilling sites and a set of data was analysed to know the compliance with the standards set by the CPCB (Table 4.15 and 4.16).

Table 4.14: National Ambient Air Quality Standards

Location	Concentration in microrgrams per cubic meter			
	SPM	**SO_2**	**CO (mg/m^3)**	**NO_X**
Industrial and mixed use areas	500	120	10.0	120
Residential and rural areas	200	80	2.0	80
Sensitive areas	100	30	1.0	30

Table 4.15: Result of various Air pollution parameters around a drill site in Assam (values in $\mu g / m^3$)

Parameter	Pre drilling	Drilling	Post drilling
Suspended Particulate Matter (SPM)	55	85	58
Oxides of Nitrogen NO_x	20	40	22
Sulfur oxide SO_2	3	5	2

4.16: Results of various Air pollution parameters around a drill site in Andhra Pradesh, (values in μg / m^3)

Parameter	Pre drilling	Drilling	Post drilling
Suspended Particulate Matter (SPM)	60	85	68
Oxides of Nitrogen NO_x	28	45	30
Sulfur oxide SO_2	8	11	12

Air quality data analysis

The measured values of the air quality, expressed as annual averaged, measured at various locations are compared against the National Ambient Air Quality Standards set by the CPCB. Thee following are the parameters analyzed to study the impact on the air environment.

Sulphur Dioxide

The result of the study indicate that the SO_2 in the drilling sites during the drilling operation were 5 μg/ m^3, 3 μg/ m^3 and 2 μg/ m respectively during the pre drilling, drilling and post drilling operations at drilling site in Andhra Pradesh. it was 12 μg/ m^3 during post drilling, 11 μg/ m^3 during drilling and 8 μg/ m^3 pre drilling stage at Assam. When compared with CPCB standards the hazards from air pollution seemed to be insignificant as far as SO_2 concentrations in ambient air went as it was well within the permissible limit of the National Ambient Air Quality of CPCB. This implies that the SO_2 concentration has no impact on the air quality of the drilling site.

Oxides of Nitrogen

Nitric oxides, formed under high temperature combustion process. Among oxides of nitrogen (NO_x), nitric oxide (NO) and nitrogen oxide (NO_2) are important. NO_2 in the range of about 120 μg/ m^3 over a six – month period is considered to produce adverse effect on the respiratory organs. The combined effect of NO_2 and SO_2 even at lower levels has adverse effect on plants. It has corrossive effect on material and is highly toxic to human beings. The residence time of NO_2 in the atmosphere is about three days, while for NO the residence time is approx. four days.

Recent studies show that nitrogen dioxide adversely affects lung defense mechanism and severely damages lungs when found in doses greater than 50 ppm. Once inhaled, NO_2 is retained in the lungs and is deposited in the lining of the trachea. In the presence of moisture, it is transformed to nitrous and nitric acids. These oxides, if transferred across the lung-blood barrier, produce inactive forms of hemoglobin known as 'meta-hemoglobin'. Eye and nasal irritation will arise after a brief exposure to 25 ppm of NO_2 in ambient air. Exposure to 150 – 200 ppm of NO_2 in the atmosphere may lead to the gradual development of fatal pulmonary fibrosis.

The results of the study indicate that the NO_x was about 40 µg/ m^3 during the drilling activity and 20 µg/ m^3 at pre drilling stages and 22 µg/ m^3 during post drilling operation at Assam and 45 µg/ m^3 during drilling stages, 30 µg/ m^3 during pre drilling stages and 28 µg/ m^3 at Andhra Pradesh respectively clearly indicating that the values are well with in the permissible limit set by the CPCB.

Hydrogen Suphide

Hydrogen Sulphide (H_2 S) is a highly toxic and colourless gas, which at higher concentration causes server iritation and develops respiratory disorders. During the exploration stages H_2 S emitted are converted into less sulphur dioxide by means of flaring. The study results indicate that the Hydrogen Sulphide (H_2S) were found to be below detectable levels at both the sites and did not pose any threat to human health.

Ozone

Ozone (O_3) is produced as a by-produce from the reaction of nitric oxide with hydrocarbon vapour in the presence of sunlight. In this 'photochemical reaction', several other compounds are formed. At a concentration level of 40 µg/m^3 , ozone can be detected by its odour. At a concentration level of about 600 µg/m^3 , ozone may cause irritation on the skin even for a short duration exposure. More severe effects of ozone exposure are alternations in the airway resistance and pulmonary edema. Data on ozone were not available.

Carbon Monoxide

The effect of carbon monoxide (CO) on the human body is dependent on its quantity in the body and upon the balance between intake and excretion by the human body. CO is also produced under natural conditions in the human body due to breaking down of haemoglobin- a process that permits recycling of iron in the blood. The CO also strongly binds with the haemoglobin which means that a small fraction of CO when inhaled will combine more firmly in the lungs with the blood steam to form carboxyhemoglobin (COHb). When this happens, the capability of haemoglobin to carry oxygen to body tissue is reduced. It has been observed that a CO level of 50 ppm leads to an equilibrium value of 7% COHb and 100 ppm of CO level to about 14% COHb. At levels greater than 5% of COHb, there are cardiac and pulmonary function changes. The results of the study conducted at the drilling sites indicate that the CO emissions were below detectable level (BDL).

Noise Pollution

Noise generated during the drilling and exploration activities is mainly from the diesel engine, shale shaker, pumps, rig floor, compressor house, cellar pit, and movement of tracks, though most of the noise is generated during the short period of the drilling activity. This causes an impact on the human health and the fauna of the drilling area. While excessive noise can damage the hearing system, the extent of damage may vary from temporary to permanent hearing loss depending upon the intensity, duration and exposure to the noise. Acoustic trauma may be caused by the high intensity impulse type if noise resulting from the explosion or sudden excessive noise particularly during the oil well explosion at high-pressure conditions. Excessive noise may also cause psychological and pathological disorders. In industrial situations, these effects result in lower efficiency, reduced work and higher chances of accidents. The recommended levels are 55dBA out door and residential area, and 45 dBA for indoor areas. The observation made in the study indicate that the noise levels were high during the drilling activity in all the sites however it was back to normal upon the completion of drilling activity. Depending on the type of rigs, either mechanical or electrical, the noise levels vary. A comparative noise levels generated by of two different types of rigs, Mechanical and Electrical Rig are given in Table 4.17

Table 4.17:Comparative noise levels generated by of Mechanical and Electrical Rigs

Mechanical rig	Noise level (dBA)	Electrical Rig	Noiselevel (dBA)
Draw works with control Systems and diesel engines (450 HPx3) 2 operating	100	Draw works with systems and DC motors (900 HPx2)	70-80
Compressors (60 HPx3) 2 operating	90-95	Compressors (60 HPx4) 2 operating	80-90
Mud pumps (750 HPx3) 2 operating with diesel engines	93-97	Mud pumps (60HPx4) 2 operating	80-85
Diesel generators (350HPx2)	92-97	Diesel generators (1250HPx2) 2 operating	80
Mud processing system	85	Mud processing system	80

Table 4.18: Permissible Noise Exposure Levels

Duration of exposure (hrs)	Sound Pressure Level (dBa)
16	85
12	87
10	88
8	90
6	92
4	93
3	97
2	100
1.5	102
1	105

Soil

Soil samples were collected and analyzed from eight points representing all the directions from the drill site. The samples were within a radius of 150 m of the site. Since all 8 samples were distributed in less than 10 ha area they were considered as one composite unit. The various parameters analyzed from the sample are given in table 4.19

Table 4.19: Results of various Soil parameters analyzed around the drill site in AP

Sl.No	Parameter	Pre Drilling	Drilling	Post Drilling
1	PH	7.99	8.01	7.94
2	CEC(meq/100g)	46.3	49.3	47.4
3	Exchangeable cations & anions			
3 a	K(%)	2.3	4.3	3.5
3 b	Ca(%)	62.0	61.0	62.5
3 c	Mg(%)	25.0	23.3	23.0
3 d	Na(%)	10.7	11.4	11.0
3 e	N(mg/kg)	6.805	7.414	7.420
3 f	P(mg/kg)	33.06	44.00	37.625
4	Bacterial density (no * 10^8 / g)	1.82	1.84	1.54
5	Zinc (ppm)	83	36	44
6	Lead (ppm)	16	16	15
7	Barium (ppm)	439	342	353
8	Manganese (ppm)	0.057	0.050	0.058
9	Iron (ppm)	3.10	3.04	3.38
10	Chromium (ppm)	58	85	93
11	Titanium (ppm)	1.09	0.86	1.19

The next chapter deals with the perception of the affected people residing in the vicinity of the exploration sites. The perception pertains to various kinds of impacts of oil exploration activities on their livelihoods.

CHAPTER 5: ENVIRONMENTAL IMPLICATIONS-A SOCIO-ECONOMIC ANALYSIS

The present chapter was designed to find out the socio-economic impacts of oil and gas exploration viewing it from the perspective of the local people. This is necessary to throw light on the perceived environmental impacts of oil and gas exploration, the awareness of people and the long-term implications of exploration activities. The villages for the study are chosen from Andhra Pradesh and Assam. It can be seen from Table 5.1 that Knowarpur has the highest number of drilled wells and for the longest period of operation as well. Karavaka Village area in Assam has the maximum number of drilling sites. In Assam a total of 150 drilling rigs were there. In the recently developed area like Krishna Godavari basin relatively few wells are operating. Here a total of 106 rigs are operating. This information is in conformity with the years of operation in these areas.

Table 5.1: Data on drilling in the areas

Name of the Village	No of Wells drilled	No.of years in operation
Kesanapalli (Andhra Pradesh)	45	6 years
Karavaka (AP)	23	3 years
Ethavaka (AP)	38	4 years
Konwarpur (Assam)	95	12 years
Hatipati (Assam)	55	9 years

Socio-Economic Survey

Oil and gas exploration and development involve various activities that impact not only the environment at large but also effect the livelihood of the people in vicinity. The intensity of such activity produces a variety of effects, which vary with the development site. As with any assessment activity the likely social and environmental impacts of oil drilling activities are especially important to all local groups, particularly to the local people. Exploration and production activities induce considerable economic, social and cultural impacts on local community, the extent of which varies according to specific situations. Local people often examine any projected resource exploitation activity in ‘their area’ in terms of how valued elements of their environment and society may alter. Social effects may be adverse or beneficial, depending upon the structure of the existing community and the nature, size and duration of operations in the region. The present study proposes to capture people's perception about ONGC's activities amongst the local people. Social impacts can include changes in:

- Land –use patterns such as agriculture, animal husbandry, livelihood, fishing, as a direct consequence or indirectly, by provision of new access routes
- Population levels (for example, from increased in-migration)
- Socio-economic systems (employment, income differentials, *per capita income,* etc)
- Socio-cultural cultural systems (social structure, organization, and cultural practices and beliefs)
- Availability of, and acces to, goods and services (housing, medical, educational).

As a part of the study a detailed socio-economic survey was undertaken at different sites in the study areas to assess the people's perception of ONGC's activities in the area. This survey was carried out to find out the impact of oil and gas exploration on the socio-economic life of the people in the neighborhood of the activity. For this survey, a total of five villages were selected and three from Andhra Pradesh and two from Assam. The villages chosen for survey are Kesanapalli, Karavaka and Ethakota in Andhra Pradesh and Konwarpur and Hatipati in Assam.

A random sampling was used where in the investigators had discussions about the awareness of ONGC activities and the related environmental issues concerning exploration activities. A structured questionnaire was used to capture the various perceptions about the community such as standard of living before and after ONGC operations started, level of pollution, etc. The questions were mostly qualitative in nature as the respondents were not able to quantitatively asses the responses for a subjects like awareness of environmental impacts. The results are presented here.

Results of Socio – economic survey of households

The sample size is uniform, of households, in each village. In that way we have 60 households in Andhra Pradesh, and 40 in Assam. Basic features like location, educational details, occupation, income level, live stock parameters, land holding patterns, crops grown and yield, etc for various sampling locations in AP and Assam are as given and discussed in the tables from 5.2 to 5.15

Table – 5.2: Location of the Sample Villages: Andhra Pradesh

Village	State	No.of Samples
Kesanapalli	Andhra Pradesh	20
Karavaka	Andhra Pradesh	20
Ethakota	Andhra Pradesh	20
Total		60

Table –5.3: Location of the Sample Villages: Assam

Village	State	No.of Samples
Konwarpur	Assam	20
Hatipati	Assam	20
Total		40

Table –5.4: Village-wise Respondents by Sex: Andhra Pradesh

Village	Male	Female	No.of Samples
Kesanapalli	16 (80%)	4 (20%)	20
Karavaka	15 (75%)	5 (25%)	20
Ethakota	18 (90%)	2 (10%)	20
Total			60

Table –5.5: Village-wise Respondents by Sex: Assam

Village	Male	Female	No.of Samples
Konwarpur	11 (55%)	9 (45%)	20
Hatipati	13 (65%)	7 (35%)	20
Total			40

The data reveals that the male population is more in the study area than female populations. This due to the fact that the drilling operations are either skilled or semi skilled and manpower is more important. In Assam area this difference is narrowed due to the long duration of drilling activity that is taking place. Here women are also working hard along with men to make their livelihoods.

Table – 5.6: Village-wise Educational Status of the Respondents: Andhra Pradesh

Village	Illiterate	Middle school	High school	Inter / Collegiate	No.of Samples
Kesanapalli	2 (10%)	7 (35%)	9 (45%)	2 (10%)	20
Karavaka	1 (5%)	9 (45%)	6 (30%)	4 (25%)	20
Ethakota	0	8 (40%)	11 (55%)	1 (5%)	20
Total					60

Table – 5.7: Village-wise Educational Status of the Respondents: Assam

Village	Agril. Labour	Farmer	Govt. Service	Own Business	No.of Samples
Konwarpur	4 (20%)	11 (55%)	4 (20%)	1 (5%)	20
Hatipati	3 (15%)	7 (35%)	8 (40%)	2 (10%)	20
Total					40

Education status is one of the important socio-economic indicators. In the study area it was found that they have middle class level of educations. Both in Andhra Pradesh and in Assam the middle level of schooling and high school level of education is nearly 70%. The education status has an impact on the occupation levels and the potential for higher

earnings.

Table –5.8: Village-wise Occupation status of the Respondents: Andhra Pradesh

Village	Agril. Labour	Farmer	Govt. Service	Own Business	No.of Samples
Kesanpalli	5 (25%)	8 (40%)	8 (40%)	3 (15%)	20
Karavaka	6 (30%)	4 (20%)	4 (20%)	6 (30%)	20
Etakota	4 (20%)	5 (25%)	5 (25%)	3 (15%)	20
Total					60

Table –5.9: Village-wise Occupation status of the Respondents: Assam

Village	Agril. Labour	Farmer	Govt. Service	Own Business	No.of Samples
Konwarpur	7 (35%)	3 (15%)	3 (15%)	4 (25%)	20
Hatipati	3 (15%)	7 (35%)	7 (35%)	2 (10%)	20
Total					40

The above two tables indicate the occupational status of the local population based on the sample results. Many of them (60 to 70%) are either agricultural labourers or farmers. As a part of the ONGC drilling operations there is scope to establish small business establishments related to servicing sector. The data shows that one fourth of the surveyed households indicated that there are engaged in two business.

Table – 5.10: Income Level of the Sample Respondents (Rs. / Annum):Andhra Pradesh

Village	Below Poverty Line		Above Poverty Line		No.of Samples
	Upto 7500	7500 - 11000	11000 - 25000	Above 25000	
Kesanapalli	5 (25%)	8 (40%)	3 (15%)	4 (20%)	20
Karavaka	6 (30%)	4 (20%)	6 (30%)	4 (20%)	20
Ethakota	4 (20%)	5 (25%)	3 (15%)	8 (40%)	20
Total					60

Table – 5.11: Income Level of the Sample Respondents (Rs. / Annum):Assam

Village	Below Poverty Line		Above Poverty Line		No.of Samples
	Upto 7500	7500 - 11000	11000 - 25000	Above 25000	
Konwarpur	7 (35%)	3 (15%)	4 (20%)	6 (30%)	20
Hatipati	3 (15%)	7 (35%)	2 (10%)	8 (40%)	20
Total					40

The study focused upon the income levels of the households. As stated earlier, education, occupation, contribute to earning potential. Taking the poverty level as a major seperation point the household are sub classified into Below Poverty with income of less than Rs.7500, and between Rs.7500 and 11,000. Similarly for the above poverty level income groups the major separation is between Rs.1,000 to 25,000, and above Rs.25,000. Three out of five house hold are below the poverty line. Their salaries / wages are so small that they depend mostly on daily wages and the work at the drill sites is short lived. They are mostly migrant works moving along with the rig sites.

Table – 5.12: Livestock particulars of the Respondents (in numbers): Andhra Pradesh

Village	Sheep / Goat	Cow / Buffalo	Hen / Birds	Other Draught Animals	Total
Kesanapalli	23 (45%)	8 (15.6%)	14 (27.5%)	6 (11.7%)	51
Karavaka	16 (36.4%)	4 ((9.1%)	16 (36.4%)	8 (18.2%)	44
Ethakota	24 (33.8%)	7 (9.9%)	28 (39.4%)	12 (16.9%)	71
Total					166

Table – 5.13: Livestock particulars of the Respondents (in numbers):Assam

Village	Sheep / Goat	Cow / Buffalo	Hen / Birds	Other Draught Animals	Total
Konwarpur	37 (38.1%)	11 (11.3%)	36 (37.1%)	13 (13.4%)	97
Hatipati	33 (36.2%)	6 (6.5%)	48 (52.7%)	4 (4.4%)	91
Total					188

The srilling operations will have impact on side noise levels and other water contaminations, it was felt that the livestock is one of the indicators to examine the environmental impact of the oil and gas drilling operations. The following two table identified the most commonly possessed animals like, sheep / goat, cow / buffalo, hen / birds. And other draught animals. Possession of sheep/goat are very common in Andhra Pradesh where as hen / birds are common in Assam. However cow/buffalo are important for the livehood of many of the households for milk and other nutrition purposes.

Table – 5.14: Landholding pattern of the Respondents (in acres):Andhra Pradesh

Village	Irrigated Land		Unirrigated Land		Land less	Total Resp
	Resp. No	Land size	Resp. No	Land Size		
Kesanapalli	8	69.25	7	17.45	5	20
Karavaka	4	28.30	10	30.15	6	20
Ethakota	5	37.85	11	38.75	4	20
Total						60

Table – 5.15: Landholding pattern of the Respondents (in acres):Assam

Village	Irrigated Land		Unirrigated Land		Land less	Total Resp
	Resp. No	Land size	Resp. No	Land Size		
Konwarpur	3	18.65	10	36.15	7	20
Hatipati	7	28.75	10	44.45	3	20
Total						40

The important criteria that effects the livelihood of the households is the possession of land for agricultural purposes. The above two tables analysis the size of land holdings in Andhra Pradesh and Assam, based on the ground realities. In Andhra Pradesh, only 17 out of 60 indicated that they possess irrigated land (less than 25%). The Assam this percentage is about the same. But there are many household possessing un-irrigated land in both the states. This is one of the causes why the households remain below poverty line. Also the wages are low and uncertainity of emplyment during the year.

Table – 5.16: Crops grown and yield (tonnes):

Crops	Area in Acres	Yield in Tonnes
Paddy	87.00	194.01
Wheat	44.50	72.54
Sugarcane	65.50	226.40
Sorghum	73.65	72.18
Pulses	53.50	47.62
Others	25.60	19.20
Total	349.75	631.95

Finally the types of crops grown is predominantly paddy in both the states. The second highest is the sorghum followed by sugarcane and pulses, and wheat.

In summary the above analysis brings out into focus about the importance of the well being of the agro ecosystem for the village economy, as the data shows the importance of the agrarian economy.

Analysis of the ONGC and its operation in relation to the selected villages in terms of its distance, number of family member working in ONGC, land given out to ONGC, area of land given to ONGC etc are as given in the tables from 5.71 to 5.26.

Table – 5.17: Distance from the Village (in Kms): Andhra Pradesh

Village	Distance
Kesanapalli	1.3
Karavaka	1.6
Ethakota	1.8

Table – 5.18: Distance from the Village (in Kms): Assam

Village	Distance
Konwarpur	0.9
Hatipati	2.0

Drilling operations are noisy, and men and machine work throughtout the day and the local popultion and livestock are disturbed. The level of noise depends upon the distance of the residence from the drilling site. As expected, the nearer the drilling location the more will be the distrurbance. It was found that in Andhra Pradesh the locations are about 1.5 km where is in Assam they are scattered. Assam being sparsely populated this may be the case.

Table – 5.19: Whether any family members work in the ONGC field:Andhra Pradesh

Village	Yes	No	Members Working
Kesanapalli	19	1	36
Karavaka	16	4	32
Ethakota	20	0	45

Table – 5.20: Whether any family members work in the ONGC field:Assam

Village	Yes	No	Members Working
Konwarpur	18	22	21
Hatipati	14	6	26

Table – 5.21: whether any land given to ONGC? Andhra Pradesh

Village	Irrigated			Unirrigated			Total
	Upto 1	1 - 2	2 - 3	Upto 2	2 – 4	Above 4	
Kesanapalli	5	6	3	5	1	--	20
Karavaka	7	3	--	6	2	2	20
Ethakota	4	4	1	5	4	2	20

Table – 5.22: whether any land given to ONGC? Assam

Village	Irrigated			Unirrigated			Total
	Upto 1	1 - 2	2 - 3	Upto 2	2 – 4	Above 4	
Konwarpur	22	5	3	4	5	1	20
Hatipati	3	4	22	7	2	2	20

Table –5.23: Acres of Land Provided to ONGC & compensation Received by the Respondents: Andhra Pradesh

Village	Wet	Dry	Total	Compensation
Kesanapalli	37.90	16.30	54.20	1626000
Karavaka	41.15	21.25	62.40	187200
Ethakota	27.85	29.60	57.45	1723500

Table –5.24: Acres of Land Provided to ONGC & compensation Received by the Respondents: Assam

Village	Wet	Dry	Total	Compensation
Konwarpur	13.10	18.20	31.30	939000
Hatipati	14.92	14.68	29.60	888000

Table – 5.25: Period of Lease (in years):Andhra Pradesh

Village	Upto 5 years	5 - 10	Total
Kesanapalli	16	4	20
Karavaka	12	8	20
Ethakota	14	6	20

Table – 5.26: Period of Lease (in years):Assam

Village	Upto 5 years	5 - 10	Total
Konwarpur	8	12	20
Hatipati	11	9	20

The above tables provide a linkage between the population and their association with ONGC operations. The first question was whether any of the local residence are employed by ONGC. The response was very positive and in both the states it was reported that half of their family members are working with the organization. Here the response was nto 100 percent. Only some of the households responded to this question. Therefore the totals are not equal to 100%. Similaly the question was related to the land acquired by ONGC and the related compensation given. In Andhra Pradesh ONGC acquired land mostly from the irrigated agricultural farmers. In Assam the distribution is equal. The point it that if it is irrigated land the compenssation must be high. In general, in Andhra Pradesh the compensation was about Rs.1,00,000 per year per hectare. In Assam also they were provided compensation. But these numbers are not reliable due to internal transactions that took place between various parties. The period of lease is up to 5 years in many cases in Andhra Pradesh where as in Assam more than 5 years. This a factor to be noted. In Assam the oil wells have a longer production period than in Andhra Pradesh.

Community perceptions on environmental impacts on account of ONGC activities, for instance the changes in quality of life, effect on prices, social costs like crime rate, ill health, pollution aspects like noise, air, water, odour, impact of pollution on health agriculture and livestock are presented in tables 5.26 to 5.55.

Table. 5.26: Quality of Life / Social Benefits (percentages)

Items	Good	Satisfactory	Bad	Total
Literacy Rate	33	57	10	100
Employment Opportunity	24	65	11	100
Awareness on Environment	36	53	11	100
Awarness on ONGC operations	15	62	23	100
Infrastrucure Facilities	38	40	22	100
Sanitary condition	14	62	24	100
Labour Migration	23	59	18	100

Here the analysis is carried out on a percentage basis, depending upon the perception of the individuals. The above table shows only the perceptions, or preferences expressed by the number of respondents. A majority of them have indicated that the quality of live is satisfactory after the presence of ONGC. Especially, the employment opportunities are more satisfactory in both the status. The sanitary conditions, and infrastructure facilities are also improved. One can say that is positive impact in this regard. More people are ware of ONGC operations and the associated environmental impacts.

Table.5.27: Economic Benefits

Average No. of	Employment opportunities		Total
	Direct	Indirect	
Persons	160	68	228
Days	220	220	440
Wage / Earning per day (Rs.)	115	80	195

Table. 5.28: Effect on Prices (%)

Items	Heavily Increased	Moderately Increased	Not at all increased	Total
Land value	15	68	17	100
Goods / Commodities	16	60	24	100
Cost of Living	11	69	20	100

It is expected that any industrial activity will bring externalities – both positive and negative – along with it. The above two table illustrates the impact on economic benefits and effet on process or costs. The economic benefits measured in form of employment opportunities, there was a significant amount of direct employment. those who reported our question they indicated that their wages have also improved during the ONGC actitivities. As a negative externality, there is some increase in the price level. However the data indicates that the price increase in moderate.

Table.5.29: Social Cost (%)

Items	Heavily increased	Moderately increased	Not at all increased	Total
Crime Rate	19	66	15	100
Ill-health	24	72	4	100
Infrastructure	10	63	27	100

From table. 5.27 it becomes apparent that on account of the ONGC's activities, employment opportunities of the local communities have increased although direct employment chances are more then indirect opportunities. The number of man-days provided in terms of terms of employment by both were same, with the former provided more per day. The perception of community indicates that there was certainly a rise in the average prices in areas in the vicinity of ONGC's activities (Table 5.28). Similarly, the trend indicates that there is rise in crime rate as well (5.29)

The ONGC drilling activitites have a multidimentsional impact on the society, environment, and intergenerational aspects, in a global concept. It is not easy to summarizes everything in on report but an attempt is made to identify the environmental aspects and other related issues in our domain. The following tables demonstrate the feelings of the population regarding environmental pollution –noise ,air, impact on livestock, health and other disorders for human beings and animals, impact on agriculture, flora and fauna, change in temperature, seepages, drinking water, ground water, soil fettility, and impact on agriculture etc.

Table.5.30: Environmental Pollution / Issues: Noise (average day) AP

Village	Drilling Stage	Production Stage
Kesanapalli	128	69
Karavaka	98	74
Ethakota	116	82
Average	106	73.4

Table.5.30: Environmental Pollution / Issues: Noise (average day) Assam

Village	Drilling Stage	Production Stage
Konwarpur	101	78
Hatipati	87	64

The human beings acceptable level of noise pollution has certain limit. The closure to the source the more will be difficulty a bear the noise. The data reveals that the noise levels are high during drilling stage than in production stage. Note that the levels are high at Kesanapalli than at Hatipati. The reasons is that in Kesanapalli, drilling takes place nearer than in Hatipati. In Kesanapalli the distance from the village and drilling site is less than 2Km, where as in Hatipati it is more than 2Km.

The survey indicates that there are many sources of noise pollution but drilling activity is the major source. It has been illustratedd in the beginning the types of noise pollution and its impact on human beings.

Table. 5.32: Source of Noise Pollution (%)

Items	Yes	No	Total
Drilling	99	1	100
Oil Pumping	86	14	100
Flare stake	79	21	100
Gas separator	80	20	100
Loading Point	83	17	100
Trucks moving	98	2	100
Average	88	12	100

Table. 5.33: Disorders in the family due to Noise.

Village	Persons Responded			Level of Hearing Impairment			
	Yes	No	Total	Low	Medium	High	Total
Kesanapalli	2	98	100	1	1	--	2
Karavaka	--	100	100	--	--	--	--
Ethakota	1	99	100	--	1	--	1
Konwapur	1	99	100	1	s--	--	1
Hatipati	--	100	100	--	--	--	--
Average	4	96	100	2	2	--	4

Those that were contacted indicated that the physical disorder due to noise is minimal. Only a fractionof the households indicated some disorder can be attributed to this drilling operations.

Table. 5.34: Medical Expenses involved due to Noise Pollution in an year.

Village	Resp. No	Medical Exp.(Rs) (A)	Indirect Loss (B)			Total Loss (A+B)
			Work Days	Wage Rs.	Total	
Kesanapalli	2	800	7	115	805	1605
Karavaka	--	--	--	--	--	--
Ethakota	1	450	5	115	575	1025
Konwarpur	1	600	12	125	1500	2100
Hatipati	--	--	--	--	--	--
Average		462.50	6		518.75	1182.50

In the process of survey, we went to the extent of enquiring whether they incurred any medical expenses. The data reveals that it is a very small amount in the order of Rs.450 to 800 per year, due to direct medical check up. The indirect losses are not computable exactly. But our analysis shows that some of the reported loss due to missing the work days, and the associated wage loss. Putting all together, on an average, the total loss is Rs 1182 per those who have some disorder due to nose pollution.

Table. 5.35: Reasons for Air Pollution (%)

Reasons	Yes	No	Total
Rise in Temperatures	33	67	100
Feeling Bad smell	41	59	100
Average	37	63	100

Table. 5.36: Type and characteristics of Odour

Characters	No. Responded	%
Tolerable	14	34.14
Adjustable	12	29.27
Sintolerable	15	36.59
Total	41	100

Table. 5.37: Odour Occurrences

Time	No. Responded	%
Morning hours	6	14.63
Evening hours	9	21.95
Night Time	11	26.83
All the above	15	36.59
Total	41	100

Table. 5.38: Seassonal Occurences

Seasons	No. Responded	%
Summer	7	17.07
Rainy	10	24.39
Winter	11	26.83
All the above	13	31.71
Total	41	100

Table. 5.39: Health Impact due to Air Pollution (%)

Responses	No. Responded	%
Yes	16	39.02
No	25	60.98
Total	41	100

Table. 5.40: Medical Expenses involved for treatment due to diseases (on account of air pollution) (Rs./Year)

Sl. No	Disease	Resp No	Medical Exp(Rs) (A)	Indirect Loss			Total Loss (A+B)
				Work Days	Wage Rs.	Total (B)	
1	Cough	2	185	6	115	690	875
2	Cold	3	90	4	115	460	550
3	Breathlessness	5	400	8	115	920	1320
4	Wheezing	3	100	2	115	230	330
5	Phlum	1	60	3	115	345	405
6	Headache	2	50	2	115	230	280
Average		16	147.50	4.17	115	479.17	626.67

Next to noise pollution, air pollution is the most common for health disorders. Here an attempt is made through our socio economic survey to find out reasons for air pollution, characteristics of odour, frequency of occurrence of this odour, health impact, and medical expenses incurred due to health disorders.

All the respondents were able to react to the air pollution effects. Only one third of the respondents identified that there is air pollution and it was felt in the form of rise in temperature, feeling bad smell.

As far as the tolerance level of the odour caused by the air pollution, it depends on the dispersion and velocity as well as direction of wind flow. Those who noticed any odour onoy 34.14% said that it is tolerable, and a similar percentage (36.59) said that it is intoletable. However this is a function of wind velocity, direction, and the time of the day.

As stated in the above Para, the feeling of odour is a time dependent,and seasonal also. The respondents were not clear about the time of the day they feel about it. The result indicates that they feel in morning hours, evening hours, and night hours.

With regards to the seasonal occurrence of this odour/ air pollution effect, the population is equally divided in identifying the seasonal changes. Generally in the winter season we feel more smell compared to summer months. This is the result noted in the survey also. For example 31.71% of the surveyed population informed that they feel all the seasons.

The common health disorders due to air pollution are cough, breathlessness, wheezing, phlum, and head ache etc. in the survey very few people indicated any of the health problems. But the medical expenses for treatment are also marginal, to the order of Rs.50 to 400. This may due to neglect or they may be approaching a government physician, or a local free medical camp. Indirect expenses are relatively high and they are of the order of Rs.230 to 920. The total column indicates the direct and indirect medical expenses, and on a average, per person, it is about Rs.626.

Table. 5.41: Impact on Livestock health

Responses	No. Responded	%
Yes	6	6
No	94	94
Total	100	100

Table. 5.42: Symptoms Identified and Medical Expenses on Cattle due to Air Pollution.

Sl. No	Disease	Resp No	Medical Exp(Rs)
1	Feverish	2	150
2	Not Drinking Water	3	100
3	Breathlessness	5	300
4	Wheezing	3	100
5	Others	1	260
Average		16	182

Another impact aspect of our socio economic survey is to identify the environemental impact of oil and gas drilling activities on livestock. In this case the respondents are very negligible. But they indicated that the major symptoms are fever, no drinking water, breathlessness, wheezing etc. the medical expenses were very small in the order of Rs.100 to 300. One can say that the impact on livestock is negligible.

Table. 5.43: Impact on Agriculture (%)

Impacts	Yes	No	Total
Change in Soil Texture	36	6	42
Hardenty	40	2	42
Less Yield	39	3	42
Increased operational cost	38	4	42
More input consumption	41	1	42
Change in cropping pattern	35	7	42
Others if any	37	5	42
Average (%)	38 (90.48)	4 (9.52)	42 (100)

Table. 5.44: Impact on flora and Fauna (%)

Impact	Yes	No	Total
Affecting Plant Growth	18	82	100
Affecting Plant's Colour	22	78	100
Affecting Yield Rate	17	83	100
Affecting Product's Taste	6	94	100
Average	14	84	100

Table. 5.45: Change in soil Fertility (%)

Village	Yes	No	Total
Kesanapalli	43	57	100
Karavaka	40	60	100
Ethakota	36	64	100
Konwarpur	47	53	100
Hatipati	44	56	100
Average	42	58	100

The next important factor of interest is the impact assessment on agriculture and, flora and fauna, in the neighborhood Overall. Less than half of the household indicated some impact on the agricultural yield. This cannot be confirmed because the respondents are those have either irrigated land or un-irrigated land. The changes that were notices are, change in sil structure, increased hardness, less yield, increased operational cost, more input consumption, change in cropping patter, etc.. This needs more probing at a micro level. But the general impression is that ONGC is taking every care to see that irrigated lands will not be contaminated. There are some instances, that coconut trees have been effected but the proof is yet to be established. Similarly, there is no significant impact on flora and fauna.

An attempt was made to analyse the soil fertility situation, within our parameters. A simple question regarding any change in soil fertility in the study area revealed that less than half of the respondents said thereis an impact. But majority (more than 50%) did not find any change in soil fertility.

Table. 5.46: Change in Temperatures. (Percentage)

Village	Increased	No Change	Decreased	Total
Kesanapalli	23	74	3	100
Karavaka	31	69	--	100
Ethakota	28	68	4	100
Konwarpur	39	61	--	100
Hatipati	36	62	2	100
Average	31.4	66.8	1.8	100

Table. 5.47: Seepages.(Percentages)

Items	More seepage	Not much	No seepage	Total
Water streams	6	22	72	100
Irrigation canals	7	19	74	100
Ponds / Tanks	13	30	57	100
Wells / Bore wells	11	226	63	100
Average	9.25	24.25	66.50	100

As a part of drilling activity the local temperature will increase. However due to the source of heat generated its dispersion will reduce the heat at longer distances. The respondents reported no major increase in temperature. The survey results show that only one third have indicated some change in temperature.

As a part of waste water discharged, or at the group gathering stations (GSS), a certain amount of oil seepage is expected. It enters water streams, irrigation canals, ponds, tanks, wells, and bore wells. They analysis shows no seepage into these sources. One in four indicated some seepage.

A major source of contamination in any environmental damage is water quality. Any environmental assessment of a major industrial activity is not complete unless water quality is acceptable to human consumption, livestock, or for irrigation purposes. Here the quality of water is tested for surface water and ground water. The following tables offer the survey results.

Table. 5.48: Impact on Drinking Water (Percentage)

Village	Yes	No	Total
Kesanapalli	22	78	100
Karavaka	19	81	100
Ethakota	26	74	100
Konwarpur	23	77	100
Hatipati	25	75	100
Average	23	77	100

Table. 5.49: What are the Impacts / Contaminations in drinking water.

Impacts	High	Moderate	Meagre	Total
Change in Taste	4	12	7	23
Change in Colour	6	10	7	23
Odour	3	14	6	23
Fluorides	8	6	9	23
Oil / greasy	11	8	4	23
Average	6 (27.82)	10.0 (43.48)	6.7 (28.7)	23 (100)

Table. 5.50: Sources of contaminations.

Sources	No. Responded	%
By ONGC	16	69.57
By Nature itself	5	21.74
By Other sources	2	8.69
Total	23	100

Table. 5.51: Affected by any Human Disease due to water contaminations

Diseases by	Yes	No	Total
a) Viral: Viral Hepatitis, Poliomyelitis etc.	4	19	23
b) Bacterial: Cholera, Typhoid, Paratyphoid, Bacillary dysentery, Esch.coli diarrhoea, Rota virus diarrhoea (in infants) etc.	9	14	23
c) Protozoal: Amoebiasis, Giardiasis etc.	3	20	23
d) Helminthic: Round warm, Whip warm, Thread warm, Hydatid disease etc.	4	19	23
e) Leptospiral: Weil's disease	2	21	23
Average (%)	4 (19.13)	19 (80.87)	23 (100)

Table. 5.52: When do you frequently suffer?

Season	No. Responded	%
Summer	4	17.40
Winter	8	34.78
Rainy	11	47.82
Total	23	100

Table. 5.53: Impact on ground water level.

Village	Decreased Heavily	Moderately Decreased	No change	Total
Kesanapalli	26	42	32	100
Karavaka	38	43	19	100
Ethakota	31	29	40	100
Konwarpur	33	39	28	100
Hatipati	28	30	42	100
Average	31.20	36.60	32.2	100

From the Table 5.50, it was found that there is no contamination of the water in the selected villages. On the average 77% of the households have no complaint. From the Table, the sources of contamination are identified. Those that are effected by the contamination were asked what are characteristics of contamination. It was stated that there was change in taste, change in colour, odour, flourides, and other oil/greas forms. In general the impact is moderate (43%). The respondents are 23, and among them the highest number of respondents indicated that Odour is the major impact. There is no clear picture about the source of contamination.

Table 5.51 indicates the possible human diseases due to water contamination. The major diseases are : viral, bacterial, protozoal, helminthic, and leptospiral. Based on the survey of 23 respondents we noticed that there is no major disorder. The biggest medical disorder is related to bacterial ifections that lead to cholera, typhoid, paratyphoid, bacillary dysentry, Esch.coli, diarrhoea, Rota virus diarrhoea (in infants) etc. Since diseases are seasonal, it was observed that the frequency of occurance is in rainy season (47.8% of the cases)

The impact on ground water potential was examined and the results are reported in table 5.53. ONGC operations, drilling will take place to depths of above 3000 metres. As a results ONGC draws a large amount of water from the ground, which can drain the ground water potential. In this case it was found that there is moderate decrease (36.6%) in the study area. Among the surveyed people 31.2% indicated decreased heavily and 32.2% indicated no change.

First. The impact on drinking water was not felt by the local population, in all villages. Only one out of five indicated some impact. But the sources of contamination are different, as expressed by the residents. The respondents were asked to identify whether the contamination is high, moderate, or meager. The parameters are change in taste, change in colour, odour, fluorides, oil/gready. Among the 23 respondents only 28% said that it is high, 44% said that it is moderate and the rest 28% indicated that it is meager. The source of contamination is generally identified as ONGC. But the natural causes also contributed to the contamination.

The second aspect is the medical / health factors due to water contamination. The commonly identified diseases are viral, protozoal, helminthic, and leptospiral. The table give more details on each of the forms of diseases. Here the total respondents are 23 and distribution indicates that 80% of the households do not experience any of the above diseases.

The perceptions of the community on various aspects of pollution caused by ONGC's activities in the area are as discussed below in a summary form.

Noise

Most people felt that the noise generation was found to be higher during the drilling phase than during production stage. The survey result suggests that the drilling activities in Kesanapalli caused discomfort in comparison with other villages while lower disturbances were recorded at Hatipati vilage which lasted only for about 87 days during the drilling phase. Regarding the source of the noise generation, it was said that the drilling activities created most, closely followed by the movement of trucks. The noise pollution from flare stake was ranked the lowest by the community. However, regarding the impact of noise on the family life, there were no negative feeling expressed in the survey. However, on economic loss front, there were exceptions recording both direct and indirect losses on account of noise pollution. The quantum of average economic losses due to noise pollution in the surveyed population was to the tune of Rs.1182.

Air Pollution

The sueveyed community held bad smell as primary reason for the air pollution in the reason followed by the rise in temperature. However, most of the community felt the odour is within adjustable limits and felt that the odour is a problem during most of the days all round the year. 40% of the surveyed population expressed negative health effects because of air pollution. Breathlessness was ranked the highest among other problems. The average economic losses both direct and indirect were to the tune of Rs.626.

Water Pollution

Oil/Grease accorded the prime responsibility for water pollution by the surveyed community. 40% of population felt the water pollution because of ONGC as moderate while 27% felt it was high. The pollution due to seepage of waste water into water bodies was recorded as grave by 35% of the population whereas 66% did not agree with this. 70% of the population felt that even drinking water was getting polluted by the ONGC activities. 67% of population felt that even the ground water table was being affected by the ONGC;s activities.

As part of the Socio-economic survey, an effect was made to study the comparative environmental awareness between the sampled villages. The results are given below.

Table. 5.54: Awareness levels of the residents about environment, AP

Name of the village	Aware of environmental pollution due to exploration activities	Not aware	Total
Kesanapalli	16	4	20
Karavaka	17	3	20
Ethakota	17	3	20
Total	50	10	60
	83.33	16.67	100.00

Table. 5.55: Awareness levels of the residents about environment, (Assam)

Name of the village	Aware of environmental pollution due to exploration activities	Not aware	Total
Kanwarpur	14 (70%)	6 (30%)	20
Hatipati	15 (75%)	5 (25%)	20
Total	29	11	40
Percentage	72.5	27.5	100.00

The awareness of ONGC operations and its impact on local residence is questioned in the survey. Tables 5.54 and table 5.55 illustrate the significance of awarness. Nearly 83% of household are aware of the environment pollution due to exploration activities of ONGC bith in Krishna Godavari basin, and Assam region.

The population surveyed at Ethakota and Karvaka recorded higher levels of information regarding the possible negative impacts of various operations related to the oil exploration activities. About 83% of the surveyed population in AP has some understanding regarding the pollution while about 16% of the sample expressed ignorance about the pollution fron ONGC operations. In comparison, the sample from Assam, the awareness about oil explorations activities and environmental pollution was registered by only 75% of population and about 25% of sample expressed no knowledge about pollution from oil operations.

Regarding the employment opportunities in view of the ONGC operations, 60% of the surveyed population in Kesanapalli felt that there was increased level of opportunities while only 55% and 9% found the same in Karavaka and Ethakota villages respectively (table 5.56). However, from the three villages, about 46%, of sampled population expressed that there was no increase in employment opportunities in view of ONGC operations (Table 5.58). The sameple from Assam differs from that of AP as only 37% of sampled population expressed that there was some increase in the employment opportunities whereas about 62% felt the oil exploration has created no new opportunities (Table 5.57).

Table. 5.56: Employment opportunities due to ONGC operations (AP)

Name of the village	**Increased opportunities**	**No change**	**Total**
Kesanapalli	12 (60%)	8 (40%)	20
Karavaka	11 (55%)	9 (45%)	20
Ethakota	9 (45%)	11 (55%)	20
Total	32	28	60
Percentage	53.33	46.67	100

Table 5.57: Employment opportunities due to ONGC operations (Assam)

Name of the village	**Increased opportunities**	**No change**	**Total**
Kanwarpur	7 (35%)	13 (65%)	20
Hatipati	8 (40%)	12 (60%)	20
Total	15	25	40
Percentage	37.5	62.5	10

Table 5.58: Perception about economic improvement of the Village

due to drilling operations (Andhra Pradesh)

Name of the village	**Improved**	**No change**	**Total**
Kesanapalli	**11 (55%)**	9 (45%)	20
Karavaka	**13 (65%)**	7 (35%)	20
Ethakota	**8 (40%)**	12 (60%)	20
Total	**32**	28	60
Percentage	**53.33**	46.67	100

Table 5.59: Perception about economic improvement of the Village

due to drilling operations (Assam)

Name of the village	**Increased opportunities**	**No change**	**Total**
Kanwarpur	9 (45%)	11 (55%)	20
Hatipati	7 (35%)	13 (65%)	20
Total	16	24	40
Percentage	40	60	100

The perception regarding the over all economic improvement on account of drilling activities are as follows:65% of the surveyed population in Karavaka felt that there was a positive impact on village economy while in Kesanapalli it was 55% and Ethakota only 40% felt that there was overall improvement in the village economy (Table 5.58). Together only 53% felt and the village economic conditions improved on account of drilling activities in AP whereas 60% surveyed population from the village of Assam felt that there was no improvement in the village economy on account of drilling activities (Table 5.59).

Table. 5.60: Perception About Social Benefits for the Village Due to Drilling (AP)

Name of the Village	Improved	No change	Total
Kesanapalli	12 (60%)	8 (40%)	20
Karavaka	13 (65%)	7 (35%)	20
Ethakota	11 (55%)	9 (45%)	20
Total	36	24	60
Percentage	60.00	40.00	100

Table 5.61: Perception about social benefits for the Village due to drilling (Assam)

Name of the Village	Improved	No change	Total
Kanwarpur	9 (45%)	11 (55%)	20
Haipai	10 (50%)	10 (50%)	20
Total	19	21	40
Percentage	47.5	52.5	100

Perceptions of the sample surveyed are similar regarding improvement in social conditions of the villages on account of drilling operations. About 60% sample from AP and only 47% from Assam sample have expressed the improvement in social conditions in the villages (Table 5.60 and 5.61).

Table 5.62: Perception about cost of living in due to drilling operations (Andhra Pradesh)

Name of the Village	Improved	No change	Total
Kesanapalli	12 (60%)	8 (40%)	20
Karavaka	13 (65%)	7 (35%)	20
Ethakota	11 (55%)	9 (45%)	20
Total	36	24	60
Percentage	60.00	40.00	100

Table 5.63: Perception about cost of living in due to drilling operations (Assam)

Name of the Village	Improved	No change	Total
Kanwarpur	7 (35%)	13 (65%)	20
Hatipai	9 (45%)	11 (55%)	20
Total	16	24	40
Percentage	40	60	100

On the impact of drilling operations on the cost of living, 65% of the sample from the village of Karavaka felt that it has gone up while on the average 60% from the three villages from AP felt that the cost had gone up because of the drilling activities.

Table. 5.64: Environmental Pollution due to drilling operations

Type of Pollution		Kesanapa lli	Karawa ka	Etha kota	Konwar pur	Hatipa ti	Total
Noise	Yes	16	17	15	13	14	48
	No	4	3	5	7	6	12
Air	Yes	5	4	6	7	9	15
	No	15	16	14	13	11	45
Water							
Ground	Yes	8	7	4	9	7	19
	No	12	13	16	11	13	41
Surface	Yes	5	6	4	10	9	15
	No	15	14	16	10	11	45
Soil	Yes	1	3	4	3	5	8
	No	19	17	16	17	15	52
Irrigation and livestock	Yes	0	1	3	2	3	4
	No	20	19	17	18	17	56

But only 40% sample from Assam felt there was some increase in the cost of living and 60% of sample felt there was no change in cost of living on account of drilling activities. In the comparative openion about the drilling operations and environmental pollution, following observations were made in the summary form (Table 5.64)..

Noise Pollution

Noise pollution, was rated as major environmental pollution from all the villages surveyed. In the villages of Andhra Pradesh noise pollution was held major environmental problem resulting from the drilling operations. However it was low among the sample from Assam village.

Air Pollution

Over all, only 25% of the surveyed sample expressed that air pollution was a problem. However, about 45% of sample from Hatipati expressed that drilling operations was a major concern from air pollution.

Water Pollution

Surprisingly, the sample expressed that the ground water pollution was more on account of the drilling operations in comparison with surface water pollution. This perception was high in the villages of Assam.

The next chapter provides some case studies which deal with some specific incidents like blow out, oil spill, etc.

CHAPTER 6 : ENVIRONEMENTAL IMPLICATIONS – SOME CASE STUDIES

Blowout

Pasarlapudi Blow Out

A major blow out in the village of Pasarlapudi in Andhra Pradesh in 1995 caused major impact on the local inhabitants, destroying crops, espacially the coconut trees and paddy fields. On 08.01.95 at 6.50 pm, there was sudden increase of gas pressure and the casting was pushed out with the result the well caught fire. Intially for about 30 days only vertical spread of flame was noticed. Later, due to damage in BOP, the fire in the horizontal direction also increased at BOP site.

The ONGC kept water unbrella around the BOP site close to the well site and barriers of around 200m to reduce the heat of the surroundings. The vertical height of flames, reported to have reduced and horizontal spread had increased during the period of visit. Due to water umbrella operation over the well site conditions evaporation of water and due to atmosphere boundary layer present, cloud formation and inversion within cloud is observed.

The Effect of Blowout

The villagers of Pasarlapudi were evacuated to a safe place thus disturbing their normal life. Though they were paid compensation, it offered very little in terms of the disturbance they have udergone like shifting of hones, disorganization and displacement of cattle and the loss of livelihood because of stoppage of work (espacially for people who were involved in dairy farming, poultry farming etc). The restoration of cultivation in the affected areas was delayed by almost one season, thus affecting the livelihood of many marginal farmers. Indirect loss due to the blowout was much higher than the compensation paid by the oil company. Besides the villagers were also affected by the chronic noise pollution caused by the hissing sound of the gushing gas at high spedd.

Ground Truth Verification

A team of NRSA scientist visited ONGC well sites in order to examine the localised stress on vegetation around the well site. Ground measurements of air and soil temperature, humidity, crop photosynthetic rate, transpiration and radiation near the well site have been measured and analyzed using LCA – 3 (Leaf Chamber

Analyser). Further discussions with officials from Revenue, Agricultural and ONGC were made to understand the economic impacts. The satellite data analysis indicates localised damage of around 200m close to the well sites were found to be in comformity with the gournd observations.

The ground truth observations showed that the temperature was around 40^0 C at 24 to 30 feet height close to the well site (150m). beyond 150m after the first row of heat protection by coconut plantations, the temperature was at uniform level as that of surroundings. Since there was no increase of temperature at ground level and sufficient stagnated water is available at the fields, the standing paddy crops even close to 150m did not show any burining symptoms. The spectral radiance measurement and leaft chamber analysis observations over paddy area close to well site and far off from the site did not show any marked difference.

Details about the damage

1. Damage on crops and coconut plantations was exaggerated and reported to be about 281 acres of wet paddy, 469 acres of coconut garden and 153 acres of Prawn tanks by state reports.

2. The A.P Pollution control board, Rajahmundry monitored the pollution levels and reported that no poisonous gases (hydrogen sulphide or sulfur doxide) were present in the atmosphere. The noise pollution was in the range of 100 to 140 decibels close to the well site to 55 decibels (normal) around 2Km radius.

The damage assessment during the ground truth analysis is as follows.

Damage to Coconut Plantation

The coconut trees within 200m radius only showed some damage.

- The coconut crows facing BOP showed complete damage.

- Damage was mostly observed at top of the canopy while middle and ground canopy level damage were not significant.

- The coconut saplings facing BOP at 150m distance showed yellowing and browing of leaves.

- The persistent high temperature of about 40^0 C at the coconut crown led to falling of the fruits near to the BOP site (200m).

- The heat tolerant focus plant was found healthy of around 150m distance.

Damage to Paddy

No damage at ground vegetation even at 150m from BOP is noticed. The paddy vrops around BOP site was at tillering to floweering stage and did not show any damage. The spectral and biophysical measurements around BOP site indicated the following.

1. The temperature measured at ground at 1m height and at 2m height indicated no rise of temperature beyond 175m from BOP.

2. The Humidity beyond 200m did not show any decrease.

3. The photosynthetic rate measures through leaf chamber analyser and spectral radiaiton observed from ground truth radiometer over paddy area close to well site and far off from well site did not show any marked difference.

The analysis of satellite data suggested localised effects (within 200m radius) due to gas well blowout, which is further corroborated by extensive ground truth data. The damage to coconut plantations in the wind direction have been observed within 200m zone over limited area. Other than that no extensive damage on cocnut and paddy crops were noticed. The noise pollution levels were high within 2 Km region around the site. The temperature values estimated from the capital data are in conformity with ground observations by ONGC suggesting the possible use of capital data for studing high tmperature phenomenon.

Impact of blowout on local people and enviornment

The second part of the survey was to find out the impact of blowout on the local people and environment. The village Pasarlapudi in Andhra Pradesh was affected by a major blowout in 1995, and the villagers still remember the impact of this blowout on their lives. A sample of 50 villagers were surveyed and questions were asked about their understanding of blowout, its affect on their life, their crops and cattle. The results of the survey of economic staus of the villagers, their understaning of the oil and gas drilling, economic benefits it brought to the villagers and other perception of the villagers about the blowout and its impact are presented in the following tables. According to the tables, majority of the households surveyed are farmers are very low. Many of them have no education or primary standard. This caused more hardship to their livelihood at the time of blow out. Now there is an improvement in the perception of employment opportunities due to ONGC, economics, improvement, social benefits due to drilling and other infrastructural benefits.

Table 6.1: Socio-economic profile of Pasarlapudi village (Andhra Pradesh)

Occupation	Farmer	Labourer	Others		Total
No	16	27	7	--	50
Income (Rs/ annum)	<. 10,000	10,000-20,000	20,000 - 50000	>50,000	
No	20	19	11	10	50
Educational Qualifications	None	Primary	Secondary	Degree or higher	
No	10	23	13	4	50
Employment opportunities due to ONGC	Increased opportunities (Perception)	No increase (Perception)			
No	16	34	--	--	50
Economic improvement	Improved (Perception)	No change (Perception)			
No	19	31	--	--	50
Social benefits due to drilling activities	Improved (Perception)	No change (Perception)			
No	23	27	--	--	50

The impact of blowout and the perception of the surveyed household is shown in the following table. About 60% of the household expressed that the rehabilitation measures are fully adequate or partially adequate. The compensation paid is also satisfactory in many cases Among the 50 usrveyed households, the majority complaint was noise and head during the blowout time. It is expected of the nature of disaster. However the normal live was very disturbed during the time and crops were damaged. The bigger blow was for coconut farmers who lost many trees in the fire, and due to the smoke emissions.

Table 6.2: Impact of blowout and measures taken by the authorities as perceived by the Villagers, number of respoendents

Control measures	Response			Total
Rehabilitation measures	12	16	22	50
Compensation paid	11	15	24	50
Noise pollution	9	16	24	50
Effect on normal life	38	11	1	50
Effect on crops	26	14	10	50
Effect on cattle	27	23	--	50
Affect on environment	9	17	24	50

The above table is a quantitative judgement of the inhabitants in that regoing. Totally 50 household were interviwed and taken their respoense on critical issues that could have affected their livesduring and after it was not adequate. Similarly, a large percentage (48%) indicated that the compensation paid was not adequate. The impact of noise pollution was also high during the normal life after the blow out was not effected. Nealy two forths of the respondents have no complaints on the normal life. About half of them complained that the blow out has damaged the crops and effected the cattle behaviour in terms of yield. For the major questions dealing with environmental impact of blow out, the response was not decisive. Just about half of the houehold have noticed the impact. It implies that, overall a marginal damage has been observed at the time of blowout and in the following period.

In a summary form the following observations were made.

i. Blowout affected the normal life of the villagers

ii. Blowout disturbed the routine of the villages, espeacially children

iii. Blowout dislocated the local people as they are shifted to new places and are brought back after normally was resored.

iv. It disturbed the cattle, their growth and their cycle as they were taken to different places away form their normal routine.

v. There was acute noise pollution, leading to headaches and nausea.

vi. It disturbed the sleep and freshness of the mind.

vii. The State Government authorites had not come to the rescue of the villagers and have no idea nor the resources to help the villages.

viii. Blowout control took long time as experts from different parts of the country and abroad made a number of trips.

ix. The local area had become warmer by increasing the temperature to about a degree.

Case Study of Marine Pollution

Jangira Village, Maharastra

The third part of the survey was conducted to find out the impact of oil spill on local and marine environment. A study was carried out at Jangira, a beach village near Alibag in Raigad district of Maharastra on the West Coast which occasionally witnesses the flow of sleeked oil fields in Mumbai High in the Offshore was belived to have spread oil and had come to shores near Alibag area and its neighborhood.

The investisgators conducted a survey on the sampled of 40 villages of different life styles found that oil sleek had disturbed the normal life of the villages. Questions were asked about the 1994 oil sleek and also about the inflow of leaked oils and other mateirls to the beach from the high seas. The economic status of the villagers of this beach village and other perceptions of the villagers about such oil sleeks and its affect on their life and environment are summaried in the following tables (Tables 6.3 and 6.4).

Table 6.3: Socio-economic profile of the Jangira Village, Maharasthra

Occupation	Farmer	Labourer	Fisherman and Others		Total
No.	15	13	12	--	40
Income(Rs/annum)	<. 10,000	10,000-20,000	20,000-50000	>50,000	
No.	8	11	11	10	40
Educational Qualifications	None	Primary	Secondary	Degree/ higher	
No.	2	13	9	6	40

Table 6.4: Perception of villagers on the impact of oil sleek on

the marine and local environment

Question	**Response**			
The oil sleek is due to oil and gas drilling	Yes	May be	Do not know	Total
Respondents	12	9	19	40
The sleek affected the life in the village	Yes, to a great extent	Partially affected	Not affected	
Respondents	23	14	3	40
Reduced the tourists traffic	Yes, to a great extent	To some extent	Not affected tourism	
Respondents	13	11	16	40
Affected the marine life	To a great extent	Partly affected	No affect	
Respondents	15	14	11	40
Affected the business opportunity of the local people	To a great extent	Partly affected	No affect	
Respondents	14	10	16	40
Affected environment	Full damage	Partial damage	No damage	
Respondents	5	22	13	40
Authorities come and clean the beaches, if there is an oil sleek	Yes	They come occasionally	They do not come at all	
Respondents	9	17	14	40

The survey conducted at Janjira village, a beach village near Alibag in Raigad District of Maharasthra revealed that at times the beach is affected because of deposition of tar balls which are brought to the shore by high tides. The tar balls were analyzed and it is found to contain hydrocarbon material, that are harmful to the marine life leading to not only revenue loss but also in local biodiversity.

A summary of the observations is given below

- Oil sleeks (due to oil and gas exploration, production and other activities) affected the marine life and beaches along the sea.
- It is very difficult tofind out the source of oil sleek, as it is impossible to search the entire sea area to find the source.
- No regulatory or monitoring system existed to report accidental oil sleeks or leaks and its effect on the enviornment.
- Oil Companies do not have the capacity to clean the water and beaches on a large scale.

Field observations from Assam oil fields

Since the study covered Assam Oil fields, a brief introduction about the historical development in Assam and the major producers, the geology, topology, land habitat is described here. This section also summarizes major environmental problems found in the first state of Oil production in India. It is to be noted that Oil production, and implementation of environmental regulation were hamperred by the militant acitivities. However, our observations were based on discussions and visual observations.

The oil fields in the state of Assam are primarily confined within the two districts of Sibsagar and Dibrugarh. At present Oil India Limited and Oil and Natural Gas Commission own oil fields. Assam Oil Company and Oil India Limited are recently nationalised and the management of Assam Oil Company is vested with Indian Oil Corporation. Now Assam Oil Company is to be known as IOC Ltd. (Assam Oil Division), and Oil India Limited (OIL). Oil and Natural Gas Commission is known as ONGC. Oil India Limited is reponsible for collection of crude from oil fields of the erstwhileAssam Oil Company and of its own Oil fields and also for its distribution to the different refineries.

Here an attempt is made to describe the operations indicating those that cause environmental damage along with visual aids. Better practice as adopted by Oil will mitigate environmental damage. Quantitative evalution of the extent of environmental damage is neither attempted nor suggested as future course of action.

The ONGC's drilling operation is reported to be causing considerable environmental damage. The operation in group gathering stations (otherwise known as Oil collecting Stations, OCS), henceforth referred as GGS is also causing environmental damage. A quick reconnaissance of the area for two-days followed by another 3 days on the spot investigation were utilized to prepare an intial environmental stauts report.

Majority of the Oil extracting wells of ONGC are located in Lakwa, Rudra Sagar and Geleki areas, all of which are within the Civil sub-Division of Sibsagar in the Sibsagar District. However, the regional Administrative Head Quarter of ONGC is located in Nazia which is about 20km from Sibsagar town within the same sub-division. To get a clear picture of the Model Operational Practice which is environmentally sound the GGS of Oil was also visited at Duliajan. The Technical Manager and the Production Manager of Oil were contacted to know about the method of operation practiced by oil in the Group Gathering Stations / Oil collecting stations and in drilling sites.

Nature of Environmental impact of Oil drilling sites

The base study area were confined to Geleki and two villages visited were namely Konwarpur and Hatipati which has a sizable number of production wells and GGS and are actively engaged in drilling operations. There are number of wells and GGS in Geleki area which is about 33km away from Sibsagar Town.

The adverse environmental impact at the drilling sites is confined to a limited area. The direct impact of drilling on the neighboring area of drilling site is enumerated by the socio economic survey with the following observations:

- Spoiling surrounding land (blight);
- Destroying plants and vegetation including crops and fibre production worms specially rare worms which produce Muga thread.
- Threat to animal grazing in oil covered land (there are reports of animal deaths).
- Damage to water and soil quality due to uncontrolled discharge of oil water in surrounding areas;
- Damage to fiber production worms caused by metallic sound of drilling operations;
- Posssible threat to human health.

Desirable and Actual Practices

The adverse environmental impact at the drilling sites may be mitigated if the desirable practice as adopted by Oil is followed. As a matter of fact thus far Oil had been observing the desirable practice whereas ONGC is not following that practice. There is a change in ONGC operations and preventive environmental practices are being adopted.

Descrable practice followed by OIL

During drilling, inputs like clay, water, saline water are required besides recycling of crude. The rejects of drilling operation are crude, water, clay, etc. in desirable practice, all inputs are maintained in container or in lined pits. Similarly, all rejects are out in lined pits instead of realising these mateirls to the surrounding. Floating oil in the pits is skimmed out and collected for dispatch to the Refineries, Practically there is no discharge of water, crude whatsoever. No subsequent burining of left over crude in pits is done. It is also required to clear up the drilling site of all civil and other construction materials when the drilling operations are completed. If the drilling site is converted into production well, the left over crude lifting looks matching to the surrounding.

Actual Practices

Drlling sites operated by ONGC were also visited. The actual practice is much inferior to desirable practice. Although at places attemps are made to store input materials separately by digging unlined pits, the rejects are nowhere contained. In low lying areas ONGC operation takes advantage by cutting a channel between the neighbouring trench and the low lying area. It is evident that the whole operation is done with utter neglect to soil quality, land and water pollution. Often at the end of drilling operation, some sort of fire cause damage to these worms, specially in many sites where the 'Sum' – Dighloti-fivre producing worm ecosystem is in proximity. Many temporary sheds are built, lot of excavation takes place to set the drilling rig, while ONGC retreats all scars are left behind.

Environmental impact of Group Gathering Stations

The extent of environmental impact of GGS is more persistent and acute as compared to drilling sites. The extent of damage at drilling sites is limited and the nature of damage is transient except the damage to the top soil which is irreversible.

Operation in GGS

In some wells, the crude is aasociated with varying degree of water content besides gas. The American Petroleum insitute's (API) specification stipulates the water content in crude should not exceed one percent for feeding to the oil refineries. Crude oil collected from different wells are brought to a GGS for processing the crude oil to refining grade by separating associated gas and water from the crude in accordance with Standard practice.

Desirable practices

It is reported that OIL follows the desirable practice in their OCS The operation is basically in closed circuit. The clean crude (not wet) both high pressure and low pressure are directly fed into the respective group units. The group units (G.U) are so designed as to receive the clean crude at different pressures such as 500 pound per square inch (P.S.I) 300 P.S.I 90 P.S.I and 30 P.S.I The high pressure gas is taken out at 250 P.S.I a part being utilised for internal conusmption like domestic connections and also for newly connected L.P.G Plant. The major part is compressed further for distribution through Assam Gas Company to consumers like Hundustan fertilizer company, Assam state Electricity Board, Assam Petro-chemicals Ltd. And many teagardens in the region. The high pressure gas is sometimes flared when assured uptake rate by Assam Gas Company falls below the commited demand. The oil (containing not more than 1% of water) is led into the tanks, then to tank firms for being pumped into the pipeline for distribution to the Refineries.

From the high pressure crude containing water from 2% to sometimes as high as 95% the high pressure gas is separated and led to high pressure gas is separated and led to pressure gas line at 250 P.S.I and fed into the wet crude from low pressure zones is then led to Three Phase Separator (TSP). A pressure of 50 to 70 P.S.I is maintained in these T.S.P. Gas, water and emulsion are seperated here. The low pressure gas at 30 P.S.I is further compressed to 250 P.S.I and fed into the pressure line. The emulsion is then led into a Emulsion treater (E.T), a certain chemical is added at the rate of 20 mg/l at a temperature of 140^{o} to 150^{o} F. The oil is separated and led into the tank while the formation water having oil content of about 250 mg/l is led into storage tanks while the formation water having oil content of about 250 mg/l is led into storage tanks for being pumped into disposal wells at a depth of 600 M to 750 M sunk for this purpose. Sometimes dry wells are also utilized for this purpose.

Such a closed circiut operation eliminates cause of air, water, and land pollution as direct impact and thereby prevents incidence of indirect impact. Only the requirement of flaring of natural gas in the event of surplus storgae requirement cannot be totally eliminated. Inthis regard OIL keeps the flaring either stopped or to a bare minimum during October – December peroid when paddy grows. During this period OIL releases the excess natural gas in a controlled way without flaring and thus keeps the storage capacity free from overloading. The associated gas contains methane and ethane and it is practically not viable to liquefy the gas by application of the required very high pressure.

Actual Practices

Apart from minor difference in the process layout and operational details the major department noticed in GGS at Rudrasagar and Lakwa area in the handling of the residues. The flaring of associated gas is required because of indecency in gas transmission facility which is yet to develop.

The crude bearing water carrying 3,000 to 5,000 mg/l of oil is conducted to a flare pit where the natural gas is also led to burn along with oil. In this process part of the water also gets evaporated. The ONGC claims total evaporation of water, zero discharge etc., and such claims are contrary to the fact, as is self evident from the result of analysis of wastewater effluent samples collected from the outlet of the flare pits of GGS.

Environmental Impact

There are flare pits out of the leaked oil. A close view of the flare pit showing boiling water along with oil getting discharge in the adjoining land. This spill is stagnating in the land surrounding and the flare pit GGS. Because of incomplete combustion, the formation of soot is excessive.

There are some naked flare pits which are neither nor enclosed within asbestos sheet with all its environmental impacts. A round-the-clock flare all round the year within 20 meters from a tea garden is bound to several tea gardens. The outlets from flare pit indicated proving zero discharge claim by was worng.

Effluent Quality

Discharge of oil containing water two flare pits of GGS have 872 and 1261 mg/l of oil contant were collected and analysed. No liquid effluent is normally permitted to be discharged on land or into water sources having oil contents more than 10 mg/l.

The findings of these study will help us in devising policy measures which will be discussed in the concluding chapter.

CHAPTER 7: POLICY RECOMMENDATIONS

In the present section, an attempt is made on the basis of some of the major observations from the study, to suggests certain policy guidllines that are intended to provide an impetus to the qualitative improvement in the environmental mangement scenario so that a harmonious relationship can exist between drilling and production of oil and gas industries and the environment.

As a integral part of better environmental management, the concerned authorities should, before the intiation of the oil and gas exploration activities, take into consideration various aspects like;

- Drill site layout and waste sump constuction
- Drilling fluid chemicals
- Resource and waste management
- Reclamation of drill site and environment quality maintenance
- Environment Management system

Drill site layout and waste sump construction

The oil exploration in the study area needs to be interwined with a site selection procedure that also envisages a detailed EIA and draw environmental measures in the cenceptual and planning stage so that the impacts are within the permissible limits of the assimilative capacity based on a detailed scientific and mathematical modeling. The planning should also mandate an Environmental Management Plan (EMP) to ensure ‘ Sustainable Development’ in the study area of say 25km of the proposed plant site. Hence, it needs to be an all encompassing plan for which the proposed plant site. Hence, it needs to be an all encompassing plan for which the proposed activity, government, regulatory agencies (like the Pollution Control Board) working in the region and more importantly the affected population of the study area, extend their co-operation and contribution. Though drilling operation is a temporary development activity, the process results in the alteration of land use pattern affecting the flora and fauna as well as the ecosystem prevalent in the acquired land.

Hence a prudent approach to minimize this environmental disturbance is warranted. Vegetation clearance should be kept to a minimum for a safe operation.

At the time of waste pit construction, necessary precautionary steps need to be taken to ensure that the drilling fliud wastes and drill cuttings are suitably treated and managed. Generally, a pit is made in the ground by digging to the depth and volume equivalent to approximately 3,000 to 4,000 m^3 which is largely insufficient to handle the wastes generated. Therefore the size of this waste pit to absorb the excess waste needs to be designed in such a manner that it can accommodate all the waste that the industry generated by following guidelines / practices and design of an environmentally acceptable waste pit. Besides it is also imperative to,

- Aviod proimity of waste pits to envionmentally sensitive areas.
- Desing pits by keeping in view the duration of the drilling operation, depth of the well, possible well completions, climatic conditions of the area and season of operation etc.
- Dig waste pit sufficiently away from the drill site like at least 4.0m from the boundary of the site. The distance can be altered depending on the usable ground water / surface in the proximity as well as the surrounding land use pattern.
- Waste pit should be strategically sited on drilling location to collect the rig – waste water, spills, leaks from drilling equipment's and storm water runoff from the drill site.
- Pit dykes should be constructed to fully contain liquid volumes and prevent seepage.
- In case of multiple pit system, the compartment can be made with earthen or brick walls, with oil traps at appropriate positions.

Drilling Fluid Chemicals

The water based drilling system is generally not toxic in nature, which was evident from the analysis carried out by various studies. The composition of drilling fluid chemicals used, is determined by the physical-chemical characterisitc requirements of the mud system. It is quite complex and vary widely depending on the additives used in them as well as the geological formation drilled.

In Rajahmundry area of Andhra pradesh, it was found that the drilling fluids comprised of fresh water – based mud which consisted of fresh water, bentonite clay, inert solids like berite and additives that were to regulate the chemical, physical and biological properties of the mud.

The water generated through the drilling process can best be treated by effluent treatment plant (ETP) depending on the effluent characterisitcs and their chemical composition the level of treatment can be decided before disposing. Therefore construction of ETP should be mandated where the effluents generated can have impact on human and environment.

The injection of chemicals along with drilling is a significant factor which needs to be examinated for a detailed environmental assessment based on mud system composition which consists of fresh water, bentonite clay and inert solids like barite and other additives used to control the chemical, physical and biological properties of the mud. The mud quantity can be altered depending on the type of formation drilled, during, depth of thewell, plausible drilling complications anticipated etc. However, in cases where HSD can be replaced with low toxicity water struck pipes due to differential pressure HSD can be replaced with low toxicity water based or biodegradable spotting fluids incorporated into the mud system. In doing so conventional drilling fluid lubricants with comparatively high toxicity should be replaced by low toxicity additives like glycol derivatives, fatty acid esters etc. that are easily biodegradable. Biocides such as formaldehyde can be replaced by less toxic glutaraldehyde or isothiazolones, where are highly bio-degradable / fermentable additives.

Resource and Waste Management

One of the important drawbacks in oil and gas drilling activity is the improper resources usage and waste management. As an industrialist process the sector generates significant amount of waste by the process of drilling gulping vast tracks of natural resources such as fossil fuel, water, land, forest, etc. Hence there is an imperative needs to evolve with policy measures that not only emphasis environmental protection but also conserve natural resources by applying the principles of three major management approaches as:

- *Resource utilization,*
- *Resource management*
- *Waste management*

Resource utilization

Fresh wateris one of the major resources used in the process of drilling acitivty. The quantity of which depends on the depth of well, type of mud system, type of the geological formation drillied, duration of drilling, well complation, availability of fresh water, waste water recycling / reuse facility, efficiency of solid control system, environmental awareness of the drill site personal etc. The major water sources for drilling operations are the bore holes, canals and the river systems. Studies indicated that on a average 15 M^3 of fresh water is used per day for various requirements in the drill site and about 1,500 to 2,000 M^3 of water per drill site / oil well during the course of the drilling operations. The other various environmental resources utilized for the drilling operations are energy, land, vegetation etc the process which often results in activities that affect the ground and surface water, soil, and land use pattern, flora and fauna, land topography, air quality etc.

Resource Management

With continued demand for oil resources on an increase, the industry continues to exert pressure on various natural resources such as ground and surface water which can be minimized by introducing and effective water management programme in the drill site. The other key element of a successful environment management is to incorporate 'Conservation measures and Sustainable development' so as to put the finite resources into an optimal use. Some of the measures could include recharging of ground water, recycling, tapping renewable energy sources etc all of which can minimize pressures on the fresh water intake. Also minimum possible land should be used for drill site construction and retain as much vegetation as possible after proper and careful trimming. Land reclamation to the original status is another important policy the company needs to regulate for ecological reasons.

Waste Management

Major wastes generated during the drilling operation consists of rig wash including machinery space fluids, spent drilling fluid, drill cuttings, and other solids/liquid wastes such as spilled chemicals, used containers, formation fluids during well testing, cement returns, etc with no uniform waste management practices are followed at present. For instance it is observed that the drill cuttings and drilling fluid waste along with wastewater are stored in a single waste pit together resulting in the accumulation of a large volume of waste, which eventually becomes unmanageable due to the precipitation, it was also observed that during cases of emergencies due to critical filling of waste pit, the waste fluid from the pit gets transported to the nearby drill site for disposal. Even in the few cases where wastewater is recycled in the mud system it is done without treatment. There is also lack of *Environment Management Programmes* for handling spilled chemicals, used containers, drill cuttings, empty bags, spent oil, cement waste, drill site trash, domestic waste generated at the drill site accommodation etc thus making it important to draw site specific waste management strategies. Besides these the process also generates vast amount of wastes right from the process of generation-distribution to utilization making it important to apply efficient waste disposal systems for protecting the environment.

'The prime objective of good waste management is waste minimization' while the second option remain recycle / reuse of the waste with or without treatment. Presently there is no centralized mud processing or recycling facility at the studied drill sites.

Hence wastes generated at the drill site can be minimized both in terms of quality and quantity by reducing excess fluids introduced into the waste pit and enabling the use of smaller pits, which minimizes the amount of waste to be managed. The water containing the drill site wastes from the various activities can be diverted to the designated segment of the waste pit which can in turn be reused by providing a minor physiochemical treatment and can be utilized in mud system and other drill site requirements for other activities such as gardening, washing of shale shaker etc based on the level of treatment. The drilling fluid system should be designed in such a way so as to minimize drilled solid degeneration. Empty containers, spilled chemicals, empty sacks, spent oils etc., can be reused or sent to the vendors for plausible recycling.

Also solid control equipment system should be designed to minimize drilled solid degradation, so that more undesired solids and liquid wastes are removed from the drill fluids thus reducing the liquid waste and solid wastes generated and making it easier to handled the easily. As a policy initiative it makes important to study the benefit cost analysis of transporting drilling fluid from one site to another and study for its economic and ecological implementation.

Site Reclamation and Environment Quality Maintenance

Once the drilling operations are completed, the rig moves to another location. The process, which generates vast amount of wastes, is normally left behind without adequate site restoration work. Even the study observed that major wastes left out at the site-included chemicals, trash etc with inadequate cleaning or management plan totally absent. Therefore restoration of the site to its normal condition as it was before the drilling commenced (to a greatest extent possible) by practicing strategies followed by other international companies should be adopted.

Environmental Management System

It is important for any oil company to integrate a sound environmental management practices into the organizational business to help minimize the various environmental disturbances and associated risks. Such an Environmental Management System (EMS) would provide managerial tools that will enable one to identify the environmental aspects with respect to the drilling and various associated operations as well as the environmental impacts arising out of them. This will help in systematically setting environmental objectives and targets to implement cost effective programmes as well as activities, which respond to monitor and control environment protection.

EMS is often aimed at meeting compliance requirements and periodically relook into the changing legislation, organization policy, public concerns and respond to suitable environmental care measures.

Specific Action

On the basis of the study findings, the following specific actions were suggested with the objective of fulfilling following objectives:

- ➔ To harmonize the national regulations on monitoring the quality of surface water.
- ➔ To maintain or improve the quality of the ambient air by establishing limit values for the concentrations of pollutants, together with alert thresholds for concentrations of sulphur dioxide and nitrogen dioxide in the ambient air evaluating their concentrations and by bringing together suitable information on such concentrations in order to keep the public informed.
- ➔ To prevent major accidents involving dangerous substances and limit their consequences for man and the environment, with a view to ensuring high levels of protection throughout the community by drafting suitable disaster management strategy.

Air pollution: To reduce the emissions of heavy metals that are subject to long-range transboundary atmospheric transport and are likely to have adverse effects on human health and the environment.

Marine pollution: To establish a community framework for cooperation between oil company and community during accidental or deliberate marine pollution.

To propose measures for integrating environmental considerations in community energy policy and to timely review progress.

Environmental inspections: To ensure greater compliance, and more uniform application and implementation, of community legislation on the environment by providing for minimum criteria applicable to organizing, carrying out, following up and publicising the results of environmental inspections at all times of company environment audit.

Assessment of the effects of plans and programmes on the environment*:* To supplement the existing system for assessing the environmental impact of projects with measures to help assess, at the design stage, the environmental impact of plans and programmes linked to town and country planning.

Management Of Waste

Disposal of waste oil: To promote the safe collection and disposal of waste oils

Removal and disposal of disused offshore oil and gas installations: To protect the environment by reducing pollution from pollution resulting from disused oil and gas installations.

At the industry level, pollution control measures should include in-built process control measures and external control measures at the receiving end of the pipeline before they are discharged into the various receiving bodies.

Noise

*Action against noise***:** Noise is an impotant externality in the drilling process. In the text it has been extensively discussed about its limits and the impacts. It is recommended that the noise levels can be redword if they plan bassiers around the drilling sites. A mud or a wall or a noise absorbing sheet can be placed around the site. This is the practice in many industrialize countries to reduce the noise levels reaching the inheritants in that area. In recent years technology has been developed to reduce the noise levels at the electricity generating points as well as drilling methods that conform to the international standards.

Biosphere

Management and quality of ambient air

To establish the basic principles of common strategy to define and set objectives for ambient air quality in order to avoid, prevent or reduce harmful effects on human health and the environment.

To assess ambient air quality and inform the public, notably by means of alert thresholds.

Discharges of dangerous substances

***Other dangerous substances- protection of the aquatic and terrestrial environment of the Community*:** To harmonize legislation on discharges of certain dangerous substances into the aquatic and terrestrial environment and to take preventive action at source.

Environment

Volatile organic compounds (VOCs) resulting from the storage of petrol: To reduce losses due to evaporation of the petrol at all stages of the fuel storage and distribution chain.

Role Of Oil Companies And The Government

Pollution cases are a common phenomenon in coastal area which are a result of various causes, but oil and gas production being one of the most important contributors. In order to deal with this the Government of India has regulated various measures and besides initiating both national and international responsibilities to protect and preserve marine coastal environment. India is also a signatory to the 'Law of the Sea' which envisages protection of sea.

Some of the programs initiated by the Government of India to protect the seas are:

Coastal Ocean Monitoring and Prediction Systems (COMPAS) Programme: In order to assess the health of our oceans in environmental terms the Department of Ocean Development (DOD), Government of India initiated the Coastal Ocean Monitoring and Prediction Systems (COMPAS) during 1990-91. Under this programme the pollution related data of 25 parameters are being collected and analyzed timely and the results are published in annual reports and made available to both the Central and State Pollution Control Boards for required action.

Integrated Coastal and Marine Area Management (ICMAM)

The DOD had taken up an infrastructure development and capacity building programmes to facilitate adoption of the concept of ICMAM. Here the programme focuses on development of expertise in ICMAM oriented activities and dissemination of knowledge gained to the users like coastal states through organizing training programmes.

Monitoring of Indian Coastal waters

The Government o India initiated a national integrated project on "Monitoring of Indian Coastal waters" for a quantitative assessment of the state and extent of marine coastal pollution through the Department of Ocean Development and the Ministry of Environment and Forest under supervision of a High –level Committee.

ONGC Environmental initiatives

The ONGC (which is the nodal agency in exploration) has adopted and followed various acts/ rules and policies in order to promote eco sensitive development and avoid short and long term consequences of oil and gas exploration and production, the company has formulated a set of policies measures while taking up any exploratory and production assignments in order to maintain the environmental standards. The acts and rules followed by ONGC are given in Box- 5.1[*]. Although the practice of these policies is a matter of great concern (in fact most of the policies can not be strictly followed even if they want) they give us an insight of the aspects which they consider important in ecological point of view. Detailed policies, which are practiced by ONGC, are listed below.

BOX-5.1: ACTS AND RULES FOLLOWED BY ONGC

Environment

- The Water (prevention & control of pollution) Act, 1974 & Amendments thereafter.
- The Air (prevention & control of pollution) Act, 1981 & Amendments thereafter.
- The Environment (protection) Act and Rules, 1986.
- Hazardous Wastes (Management & Handling Rules), 1989.
- Manufacturing, Storage & Import of Hazardous Chemical Rules, 1989.

Ambient Noise Standards

- Public Liability Insurance Act, 1991 & Amendments thereafter.
- National ambient air quality standards, 1994.
- Oil drilling & gas extraction industry standards, 1996.

Safety

- Oil Mines Regulations, 1984.
- Mines Act, 1972.
- Indian Electricity Rules, 1956.
- Petroleum Rules, 1976.
- Explosive Rules, 1983.
- Factory Act, 1984.

Background photo Effluent treatment plant taken from ONGC, annual Report.

RECOMMENDATIONS

- In the oil-fields, environmental awareness must be given top priority and all sections of people should be made aware of the necessity of environmental protection.

- It is essential that ETPs are constructed in all the oil-fields for the treatment of entire effluent.

- The practice of evaporating the effluent at evaporating pits should be discontinued.

- However, so long the evaporating pits are in use, masonary walls and other structures are to be so desinged and constructed to ensure total elimination of spillages or seepages.

- Discharge of effluent to suitable underground strata or into dry-wells may be practised but it must be seen that such effluent does not mix with the aquifers of shallow or deep-tube wells.

- Ways and means must be found out to use the natural gas, so that the practice of flaring may be discontinued except for emergency.

- Regarding drill sites, the American Petroleum Institute recommendations (API RP 51, October 74) should be encouraged.

- Dissolved air floatation system wherever possible and is found to have practical application may be attempted.

- The effluent treatment plant at Rudrasagar and Borhola fields should be completed without any delay. The treated effluent, as proposed for Lakwa ETP should be injected into the formation to maintain reservoir pressure in all the fields.

- Operations must not continue where new environmental risk. The operator of a petroleum activity is not allowed to carry out any activity after the occurrence of any significant new environmental effect or risk, or significant increase in an exisitng environmental effect or risk, arising from the activity unless the new effect or risk, or increase in the effect or risk, is provided for in the environment plan in force for the acitivity.

The problem of Bio diversity is important for the sustainable development in the region where Oil & Gas exploration is taking place by ONGC. In the study are such as Krishna Godavari Basin. Assam region off shore operation this Eastern have been discussed thru the questioner & interview method addressing the stack holders. The concept of Bio-diversity is also a part of the problem faced at the time of blowouts.

In case of Kirshna – Godavari Basin there is no threat to the livelihood of the population & other species in that are due to exploration & development activities. The stockholders indicated that there was damage to flora & fauna in the nighbourhood of the blowout. The NRSA Satellite images show that the ecological balance was disrobed with in a radius of 300m immediately. After a year the planet in that one has pitched up and ecological balance has been established. In case of Assam the terrain at which OIL and ONGC operations are taking place, there is a great extent of damage to bio-diversity. It has been documented in the study the flaring of deposits of oil & grease in a common site in effect damaged flora & fauna in that area. However, due to the political instability & other terrorist activity more information could not be gathered in that lease the remedial measures can be taken up if stability is established in the region.

As par an the issue of Bio-diversity is there in operations the study in the areas has to be focused on the shore line (beaches) in Maharashtra.   The study identified the problem related to terrain complaints made by the people living in that area. The oil steak that in mined sea shore water has effected the aquatic life to some extent. But no significant damage has been reported in this area. The concept of bio-diversity needs to be examined exclusively for offshore drilling operations.

Limitations of the study

The limitations of the study are as follows:

i) The data for the study of the technical analysis of environmental pollution caused by Oil and Gas exploration was mostly confined to one single site in Andhra Pradesh. Data from multiple sites would have enabled a comparative analysis of impact levels.

ii) In the case of socio-economic survey, the sample sizes were small. This prevented us from attemptiong a rigorous statistics / econometric analysis based on the existing data.

iii) Even though the co-investigator is associated with ONGC, which is the major organization involved in exploring production activity, it facilitated only in gathering appropriate information on the identified parameters. Infact the results have been examined and discussed at a focal theme workshop held at Network for Preventive Environmental Management (Net PEM). Therefore, the survey results are credible as far as the publicity of the report is concerned. Infact the members present at the focal theme workshop included many other experts from neery EPTRI, Oil consultants, Geologist, Environmental Engineers, Environmental Economists, and experts dealing with preventive environmental management.

Proposed Guidelines for the Disposal of Drill Cuttings and Drilling Fluids (for on-shore and off-shore facilities)

Off-shore facility

Disposal of Drill Cuttings:

- Drill cuttings separated form water based mud having drilling fluid with composite toxicity i.e. 96 hr. LC_{50} value > 30,000 mg/l shall be disposed in a suitable waste disposal pit. The waste pit shall be lined to avoid ground water contamination due to leaching. The waste disposal pit system should be approved by the SPCB.

- The drill cuttings separated from low toxic oil based mud having aromatic hydrocarbon content ≥ 1%, composite toxicity of 96 hrs. LC_{50} value > 30,000 mg/l and having oil content at ≥ 5 g/Kg should be disposed off in a lined waste disposal pit.

- The drill cuttings associated with oil from hydrocarbon bearing fromation should be separted from drilling fluid, having toxicity of 96 hrs, LC_{50} value > 30,000 mg/l and oil content at ≥ 5 g/Kg should be collected in a pit and should be treated for safe disposal.

- The waste pit after it is filled-up shall be covered with a thick layer of clayey soil with proper top slope be provided. The site & design of the disposal pit shall be approved by the State Pollution Control Board (SPCB).

- Total area acquired for preparation of drill site must be restored after completion of drilling operation. The site should be handing over by licensee to the owner after restoration of the site. In case, amount is paid to the owner for restoration of site, then amount to the owner should be paid towards restoration of the site shall be decided by a committee having a nominee of the state government.

- Operators to explore additional environmentally acceptable methods for disposal of drill cuttings like injection to a formation through casing and forming, bioremediation, incineration or solidification for which prior approved to be obtained from MoEF/SPCB.

Disposal of Drilling Fluid (On-shore):

- The use of oil-based mud (diesel) should be prohibited. Only water based drilling fluid shall be permitted for drilling operation and chemical additives used for preparation of drilling mud should have low toxicity (96 hr. LC_{50} value > 30,000 mg/l). Most of the chemical additives (mainly organic constituents) used in the drilling fluid should be biodegradable.

- Barite used in the preparation of drilling fluid shall not contain Mercury > 1 mg/Kg and Cadmium > 3 mg/Kg, and chromelignosulfonate chemical additives should not be used in drilling fluid.

- Excess or unusable water based drilling fluid having toxicity level i.e. 96 hr. LC_{50} value > 30,000 mg/l shall be disposed in a suitably designed lined waste pit so as to avoid seepage and groundwater contamination. The waste disposal pit should be approved by SPCB.

- The use of diesel-based mud should be prohibited. However, if the operator intend to use oil based mud to mitigate specific hole problem, an alternate low toxicity oil having aromatic HC content ≤ 1 % and toxicity of 96 hrs. LC_{50} value > 30,000 mg/l in place of diesel should be used, for which drilling operators/ agency should inform the concerned SPCB. Such low toxicity oil should be made available at the installation drilling operation.

- Excess or unusable oil based mud (aromatic hydrocarbon content ≤ 1 %), which is used in emergency situation should be properly treated and disposed.

- Synthetic Based Mud (SBM) having toxicity 96 hr. LC_{50} value > 30,000 mg/l and chemical additives (mainly organic constituents) used in it shuld be biodegradable and excess drilling fluid shall be disposed into suitably designed lined waste disposal pit or shall be properly treated before disposal or incinerated.

- Toxicity of 96 hrs. LC_{50} studies should be based on the test conducted on the Mysidopsis Bahia species or on local marine species preferably local sensitive species.

Off-shore installation

Disposal of Drill Cuttings:

- Drill cuttings separated from water based mud having chemical addtives with composite toxicity of 96 hr. LC_{50} value > 30,000 mg/l shall comply the following conditions, for off-shore disposal:

- Drill cuttings separated from Synthetic Based Mud having toxicity of 96 hrs. LC_{50} > 30,000 mg/l should be disposed at a suitable point as per the conditions a, b, c & d above.

- Installations located 5 Km away from the shore line i.e., in high sea, it is the self responsibility of the operator to maintain the marine ecological balances in the offshore area, as the high sea does not come under the jurisdiction of SPCB.

Disposal of Drilling Fluid (off-shore)

- Only water based drilling fluid shall be permitted for drilling operation & chemical additives used for the preparation of drilling fluid should be of low composite toxicity of 96 hr LC_{50} value > 30,000 mg/l. Most of the chemical additives (mainly organic constituents) used in the drilling fluid should be biodegradable. Use of diesel-based mud should be prohibited.

- Barite used in the preparation of drilling fluid shall not contain Mercury > 1 mg/Kg and Cadmium > 3 mg/Kg, and chromelignosulfonate chemical additives should not be used in drilling fluid.

- Excess or unusable portion of water based mud of low toxicity i.e. 96 hr. LC_{50} > 30,000 mg/l and free from oil content, shall be discharged into sea as per the conditions stated under a, b, c & d above in case of discharge of drill cuttings into sea.

- The unused or non-recyclable portion of water based drilling fluid should not be disposed at a point simultaneously by more than 10 drilling wells located nearby (cluster of wells). The drilling fluid should be discharged intermittently as per the conditions a, b, c & above at a rate of 15 barrels/hr/well from a maximum of 9 wells from a cluster of wells with a time gap of minimum of 2 hours to avoid increase in SS concentration and reduction in transmittance.

- Unused or non-recyclable portion of water based drilling fluid should be disposed at appropriate depth below the sea surface to have proper dilution and dispersion with no adverse impact on marine environment.

- Drilling fluid of any composition should not be discharged in Sensitive Areas notified by MoEF.

- If the operator intend to use oil based mud to mitigate the specific hole problem, it should be intimated to the SPCB and only low toxicity oil having aromatic oil content ≤ 1 % and toxicity of 96 hr LC_{50} value > 30,000 mg/l should be used. Such low toxicity oil having aromatic hydrocarbon content ≤ 1 % should be made available at the installation during drilling operation.

(a) At the disposal point, sea bottom currents should have a sufficient velocity so as to have proper dilution and dispersion.

(b) In case, the drilling operation is close to the shore (< 5 Km) and where the depth of sea is shallow in such a case, the drill cuttings are required to be brought to the shore for on-shore disposal or transported to suitable disposal point from the shore line.

(c) The disposal point should be so chosen at least 5 Km away from the shoreline that proper dilution & dispersion takes place.

(d) The drill cuttings should not be discharged simultaneously at a same place by more than 10 drilling wells located nearby (cluster of wells). The drill cuttings should be discharged as per the above conditions, intermittently, at a rate of not more than 15 barrels/hr/well and from a maximum of 10 wells from a cluster of wells with a time gap of minimum of 2 hours to avoid increase in SS concentration and reduction in transmittance. In other words, drill cuttings about

16,200 bbl/well over a period of 45 days of drilling operation would be permitted to dispose into the off-shore area.

- Drill cuttings separated from water based drilling fluid should be disposed at appropriate depth below the sea surface to have proper dilution and dispersion, with no adverse impact on marine environment.

- Drill cuttings of nay composition should not be discharged in Sensitive Areas notified by Ministry of Environment and Forests (MoEF).

- Installation located within 5 Km away from shore should discharge drill cuttings at a suitable disposal point beyond 5 Km off the shoreline as per the conditions a, b, c & d above to avoid any adverse impact on marine eco-system.

- In case of oil based mud having aromatic hydrocarbon content ≤ 1 %, the drill cuttings separated from oil based drilling fluid and having oil content < 5 g/kg should be disposed at a suitable point as per the conditions a, b, c & d above.

- Drill cuttings associated with oil from hydrocarbon bearing formation should be separated from drilling fluid having toxicity of 96 hr. LC_{50} > 30,000 mg/l and oil content < 5 g/kg, only then it should be discharged off-shore intermittently as per the conditions given in a, b, c & d above. If not, the drill cuttings should be brought to the on-shore and disposed in a lined waste disposal pit. In such a case, site restoration procedure is same as in the case of disposal for on-shore facilities and design of the disposal pit should be approved by the SPCB.

- Excess or unusable portion of oil based drilling fluid (aromatic hydrocarbon content ≤ 1 %) which is used in emergency situation, should not be discharged into sea under any circumstance, shall be brought to on-shore and properly treated/incinerated in a treatment facility.

- Synthetic Based Mud (SBM) should have low toxicity of 96 hr. LC_{50} value > 30,000 mg/l and most of the chemical additives (mainly organic constituents) used in it should be biodegradable. The unusable portion of SBM shall be permitted to discharge into sea as per the conditions given for disposal of drill cuttings.

- Installations located within 5 Km away from the shore should discharge drilling fluid at a suitable point beyond 5 Km off the shore line to avoid any adverse impact on marine eco-system.

- If any environment friendly technology emerges for substitution of drilling fluid and disposal technology, it may be brought to the notice of MoEF and regulatory agencies. If the operator desires to adopt such environment friendly technology, a prior approval is required.

- 96 hrs. LC_{50} value studies should be based on the test conducted on the Mysidopsis Bahia Species or on local marine species preferably on locally available sensitive species.

Operational Considerations

Pollution Prevention and Cleaner Production

Many practical measures with regard to operational aspects are described in Table 5. These vary from planning considerations and integration of environmental issues into engineering design, to application of on-site procedures aimed at reducing the risk of pollution. Pro-active, preventative techniques are often more effective and efficient. In this text reference is made to ' Pollution Prevention', a concept endoresed by the international oil and gas exploration and production industry. The term 'Cleaner Production', first coined by the UNEP Industry and Environment Centre in 1989, is synonymous, and has become the recognized term used by many international and national organizations.

Proactive and preventative measures are most effective when they are coordinated through a special programme that has a high visibility with personnel. 'Pollution Prevention', 'Cleaner Production' or 'Eco-Efficiency' programmes are now becoming more common within leading companies. They usually include a programme coordinator and plan of action that has been developed with the participation of employees at all levels.

These programmes are aimed at making both organizational and technical changes in operations.

Engineering and operational techniques are now available to avoid or reduce pollution. These cover produced water treatment technologies; atmospheric emissions reduction techniques; and oil-based drilling mud wastes. A board ranging discussion on a variety of waste treatment technologies is provided in the E&P Forum *waste Management Guidelines.*

Achievement of pollution prevention goals will occur over time, partly through a transition to a process that encourages the industry to conduct a critical review of its use of materials, processes and practices, and search for ways to eliminate pollution. The evolution of technology and improved procedures are among the many factors that will effect this trasition. A practical approach to implementation encourages managers in striving to conduct operations in an environmentally sound manner, and to move up the environmental management hierarchy (that is, from treatment to environmentally sound recycling and beneficial use to source reduction).

A critical element in the adoption of pollution prevention relates to technical cooperation and capacity building. The oil and gas industry recognizes that new technologies must not be transferred in isolation, but require corresponding human skills and management system to apply them.

Waste Treatment and Disposal Techniques

If elimination of waste is not possible through pollution prevention, then waste management must be accomplished through application of another series of measure – reduction, re-use, recycling, recovery, treatment and responsible disposal – the approach inherent in UNEP's Cleaner Production programme. The methodologies which apply these principles are fully described in the E&P Forum *waste Management Guidelines.* The following text describes the development of area – specific waste management plans, which can be directly implemented at the site level.

An area-specific waste management plan directly relates the choice of waste handling and disposal options to the eco-logical sensitivities, regulatory requirements and available facilities / infrastructure of the geographical area involved. The plan should be written from the field perspective and provide guidance for handling each waste stream. In developing a plan, an exploration and production company could follow the ten general steps outlined.

Area waste management planning, implementation and review offers reassurance with regard to:

- Protection of the environment and ongoing compliance with regulatory requrements;
- Ongoing training of field personnel;
- Appropriateness of the plan itself; and
- Minimization of the volume and toxicity of the wastes.

The waste management plan should be a living ‘evergreen’ document which requires periodic review and revision.

Oil Spill Contingency Planning

All operations should properly examine the risk, size, nature and potential consequences of oil spills and develop appropriate contingency plans, including informing the community of any hazards involved. Various documents are avilable. The bases of contingency planning are the identification of risk; the planning and implementation of actions to manage risks; procedures for reviewing and testing of preparedness; and training of personnel.

Contingency planning should facilitate the rapid mobilization and effective use of manpower and equipment necessary to carry out and support emergency response operations. Exercises and training should be conducted regularly to ensure preparedness. Communications should be maintained with appropriate authorities, local communities, media, neighbouring operators, contractors and employees.

Step 1: Management approval

Management approval and support for the plan should be obtained. Management should be aware of the timing and scope of the plan. The goal(s) of the waste management plan should be established with measurable objectives for each goal.

Step 2: Area definition

The plan should be site-or area- specific and should include a description of the geographical area and operational activities addressed.

Step 3: Waste identification

Operations personnel should identify all the wastes generated within the area defined for each exploration and production activity (i.e. production, drilling, completion / workover, natural gas plants). A briefly description for each waste (sources, per cent oil and / or saltwater content and approximate volume) will assist in further management steps.

Step 4: Regulatory analysis

Review international, regional and host country laws and regulations to determine the types of wastes for which management practices should be highlighted. Waste types for which the regulations do not adequately define management requirements should also be identified.

Step 5: Waste categorization

The physical, chemical and toxicological properties of each waste should be identified via Material Safety Data Sheets (MSDS), manufacturers information, process knowledge, historic information or lab analysis. Waste can be grouped according to their health and environmental hazards.

Step 6: Evaluation of waste management and disposal options

Waste management options(s) for each waste should be compiled, and available options identified. Each options should be reviewed by appropriate operations personnel and management. Evaluate should include: environmental considerations; location; engineering limitations; regulatory restrictions; operating feasibility; economics; potential long-term liability; etc.

Step 7: Waste minimization

Waste, volume or toxicity reduction, recycling and reclaiming, or treatment should be evaluated. Revision of the waste management plan should be made to reflect any minimization practices implemented.

Step 8: Selection of preferred waste management practice (s)

Select the best practice for the specific operation and location. Life- cycle analysis including use, storage, treatment, transport and disposal should be considered.

Step 9: Implementation of an area waste management plan

Waste management and disposal options for each waste should be complied into one comprehensive waste management plan. Waste management practices should be summarized, including waste descriptions, indicating the chosen waste management and disposal practice.

Step 10: Plan review and update

Effective waste management is an ongoing process. The plan should be reviewed whenever new waste management practices or options are identified. A procedure to review and update the waste management plan should be established, and practices modified to reflect changing technologies, needs or regulations.

Source: E&P Forum *Waste Management Guidelines*[4]

Plans should clearly identify the actions necessary in the event of a spill: the communications network, the organization structure, the individual responsibilities of key emergency personnel, together with the procedures for reporting to the relevant authorities. The plan should clearly identify vulnerable and sensitive locations and tackle the problem of the disposal of recovered material, contaminated waste and debris.

Responsibility for contingency plans, their implementation, training and exercise and periodic and periodic audit and review should be clearly delegated to site staff as required under the environmental management system.

Contingency plans

- Identify risks and objectives
- Establish response strategy
- Establish communications and reporting
- Determine resource requirements
- Determine action plans
- Provide data directly and supporting information

Decommissioning and rehabilitation

Many exploration wells will be unsuccessful and decommissioned after the initial one to three months activity. It is worth planning for this from the outset, and ensuring minimal environmental disruption. Decommissioning and rehabilitation will, subsequently, be simplified.

Site decommissioning and rehabilitation is an important part of environmental management. The main purpose is to rehabilitate a site to a condition that meets certain agreed objectives. To be successful, rehabilitation plans need to be developed early in the planning process using information gathered during the assessment phase. The site needs to be prepared and managed in such a way as to ease eventual rehabilitation. In most cases progressive rehabilitation is preferable to leaving everything to the end.

Discussions with appropriate authorities and/or local communities should have been held during the planning phase to determine a preferred and feasible after-use for the site, buy may need to be reviewed and updated when decommissioning is imminent. Such discussions should occur periodically through the life of the project to check that circumstances have not resulted in a change of opinion regarding the preferred after-use. Once final agreement has been reached, a reclamation plan should be prepared. A number of rehabilitation options are available.

Rehabilitation options

- Rehabilitation to pre-development conditions.
- Partial rehabilitation.
- Rehabilitation to an acceptable alternative condition.
- No action.

In general reclamation should be based on a risk assessment process to ascertain the level required, and in some cases no rehabilitation or partial rehabilitation may be appropriate. In cases where operations have taken place in the vicinity of existing human settlements, there may be a local wish to retain roads or other useful infrastructure. Partial restoration would then involve the removal of all equipment and contaminants, but not the agreed infrastructure. The environmental consequences of retaining roads and therefore access into the area, however, need to be taken into consideration before such partial rehabilitation can be approved. The E&P Forum decommissioning guidlines describe in detail the recommended decommissioning processes for onshore E&P sites, including dealing with contaminated sites and soils clean up.

A wide range of international, regional and national legislation regulates the decommissioning of offshore structures.[37,38] The offshore oil and natural gas exploration and production industry has provided a briefing paper assessing the implications of decommissioning.

Environmentally- Sensitive Areas

The framework presented in this document should allow operators and stakeholders to understand the development and practice of environmental management and to appreciate some ecological, social and cultural sensitive related to operations. However, not all measures discussed in this framework document will necessarily be appropriate for implementation in all geographic areas or under all conditions. The reader is referred to existing guidance for activities in sensitive environments – Arctic and sub-Arctic, mangroves, tropics, tropical rain forests, coastal water, geophysical operations.

Other environments also have peculiar sensitivities and may warrant special approaches: for example, temperate woodlands, boreal forests, wetlands and marshes, freshwater and inland seas, coral reefs, arid areas.

Technology Considerations

The oil and gas exploration and production industry has been pro-active in evaluating and introducing new engineering and operational techniques aimed at pollution prevention. Improved management approaches and operational practices have been described previously, and the aim of this section is to illustrate some technological approaches to prevent and reduce pollution.

Atmospheric Emissions

A principal target for emissions reduction is flaring and venting which provide the most significant source of air emission in the industry. Many process optimization studies have been conducted by industry to identify opportunities for emissions reductions. This has led to the development of improved process control procedures, design and maintenance systems. Technological advances in value design have the potential to reduce fugitive emissions, whilst improved flare design has increased combustion efficiency. Flare gas recovery and increased NGL recovery have resulted from evolving new technologies.

Various technological initiatives have been introduced to reduce emissions as a result of combustion processes related to power production. More efficient gas turbines have been developed together with improved turbine maintenance regimes. Efficiency improvements have also resulted from gas turbines optimization considerations. Other technologies to improve fuel efficiency include: steam injection; combined cycle power generation; electric power distribution (phase compensations); pump and compressor optimization waste heat recovery; coordinated, shared power generation; and the application of energy conservation principles.

Other technologies being introduced are aimed at improved combustion performance: for example, dry low NO_x combustion (DLN) technology, selective catalytic reduction (SCR) technology, as well as water and steam injection, all aimed at reducing NO_x emission. Improved injection systems and pre-combustion in diesel engines also have the potential to reduce NO_x emissions.

Various improvements in well testing procedures and technology have resulted in reduced emissions from this source. Again optimization work has included examination of better fluid properties to improve combustion, and better operating procedures. Significant advances in burner technology and design have improved performance, such as the Schlumberger 'Green Dragon' burner, the Expro 'Super Green' Crude Oil Burner and Charbonnages de France incinerator feasibility study.

Produced Water

The second major waste resulting from the oil production process is produced water. Since water is naturally produced with the oil there is limited potential to eliminate the source. However, some progress has been made to limit water production. Water shut-off technology such as diverting gels can provide an efficient way of reducing the quantities of water requiring treatment. Reinjection of produced water, either into the reservoir, or into another formation, may provide a practical and optimum solution if suitable geological formations are available.

New technologies are emerging for the treatment of produced water, particularly related to the removal of dispersed oil. These include: skimming/gas flotation; static hydrocyclones; mechanical centrifugation; and gas stripping. Most of these technologies are currently in normal operation or have reached the stage of prototype testing. Other processes are currently being examined for potential application onshore and include: bio-oxidation and biological treatments; activated carbon filtration; solvent extraction; wet oxidation and ozonation.

Solid Waste

Many aspects of waste management are examined in reference 4, which includes examination of the potential for source reduction. However, opportunities to eliminate or decrease waste are limited because frequently their volumes primarily result from the level or longevity of activity or the state of reservoir depletion. Opportunities for reduction arise principally through process and procedure modifications. In the case of drilling fluid discharge, improved solids control equipment and new technology can reduce the volumes discharged to the environment. The development of more effective drillbits can reduce the need for chemical additions, whilst gravel packs and screens may reduce the volume of formation solids/ sludge produced. Improved controls, procedures and maintenance can help minimize mud changes, engine oil changes and solvent usage.

The search for chemicals with lower potential environmental impacts has resulted in the generation of less toxic waste, for example mud and additives that do not contain significant levels of biologically available heavy metals or toxic compounds. It has also resulted in the development and use of mineral and synthetic drilling fluids.

Re-use, recycling and recovery of waste materials has also been examined, including the use of drill cutting for brick manufacture and road bed material, use of vent gas for fuel, and the use of produced or process water as wash water. Wastes such as tank bottoms, emulsions, heavy hydrocarbons, and contaminated soils may be used in road building.

Several new technologies are being applied to waste treatment such as: biological treatment (land spreading, composting, tank-based rectors); thermal methods (thermal desorption and detoxification); chemical methods (precipitation, extraction; neutralization); and physical methods discussed above (gravity separation, filtration, centrifugation). Downhole disposal of wastes of wastes has received attention recently, not only for produced water but also for oil-based mud drilling waste.

Techniques

In evaluating and introducing new practices, the industry examines not just technologies as described above, but also techniques aimed at minimizing and eliminating environmental effects. Some drilling techniques that have been developed recently include horizontal drilling, heliportable rigs, and slim-hole drilling. Each provides a number of direct environmental advantages, such as minimizing land take and footprint, and reduction in waste material. In seismic activities the development of vibroseis on land and air guns at sea have considerably reduced the dependence upon explosives. However, it should be borne in mind that newer technologies do not always necessarily lead to best environmental practice, and an environmental assessment of which technologies or techniques are least damaging should always be undertaken. For example, in operations in forests, shot-hole techniques may be preferable to vibroseis, since there is less requirement for cutting and vegetation clearance.

The way operations are approached logistically can also provide environmental advantage. Exploration in remote and environmentally sensitive locations on land may be accessed, operated and sensitive locations on land may be accessed, operated and serviced using techniques normally applied to offshore drilling, thus eliminating the need to construct access roads. However, a balanced assessment is required in each case to determine best environmental practice.

The data that in analyzed in the report is comprehensive however more primary data is collected for onshore activities than offshore activities. The data on offshore activities is secondary data consisting of Chemical analysis done by various laboratories of ONGC and its affiliated institutions as well as independent organizations like NEERI, EPTRI, and CPCB. There is a general agreement that the pollutants that are harmful due to drilling operations are with in the limits.

In the case of onshore activities, both at KG Basin and at Assam the data is gathered both at primary level and at Secondary level. The Secondary data indicated that there is no damage locally with ref. To surface water or ground water in that area. They the agricultural activity as well as soil contamination has not been affected. The primary data collected thru the survey also indicated that the respondents do not have any major complaints about the drilling activity. During the course of drilling there is damage either in the form of none pollution or oil pollution, thru emissions in the air. But there is no significant reference in the seasonal patters in either case.

Thus it can be concluded that, based on comprehensive analysis of survey results across inshore & offshore sampled regions, has no significant difference. It may be stated that to make such a comprehensive analysis an independent study can be conducted in these regions.

Drilling Mud Additives used in Non-Hazardous Drilling Mud

Sl No.	Name of Additive
1	Aluminium Stearate
2	Attapulgite Clay
3	Bagasse (Dried sugar cane)
4	Barium sulfate
5	Bentonite
6	Clacium carbonate
7	Causticised lignite(Sodium lignite)
8	Cellophane
9	Chrome free Lignosulfonate
10	Cotton seed pellets
11	Diamines and fatty acid amides
12	Detergents
13	Ethylene oxide adduets of Phenol and nonylphenol
14	Guar gum
15	Hydroxythyl cellulose
16	Lecithin
17	Lignite
18	Magnesium oxide
19	Methanol
20	Mica
21	Morpholine polyethoxyethanol
22	Nut shells
23	Paraformaldehyde
24	Peptized acid
25	Phosphoric acid
26	Polyacrylamide resin
27	Polyanionic cellulosic polymer
28	Polysaccharides
29	Potassium chloride
30	Potsaaium hydroxide
31	Potassium sulfate
32	Pregelatinised corn starch
33	Quartz or cristobalite
34	Rice husks
35	Saw dusi
36	Shredded paper
37	Sodium acid pyrophosphate
38	Sodium bicarbonate
39	Sodium carbonate (Soda ash)
40	Sodium carboxymethylcellulose
41	Sodium chloride
42	Sodium hexametaphosphate
43	Sodium hydroxide (caustic soda)
44	Sodium montmorillonite clay
45	Sodium polyacrylate
46	Sodium tetraphosphate
47	Starch
48	Tetrasodium pyrophosphate
49	Tributyl phosphate
50	Vegetable&polymer fibers
51	Vinyl acatate
52	Xantham gum (xc polymer)

Indian Standards for Air, Water, and Solid Waste Disposal

A: Standards for Liquid effluent

On-shore facilities (for marine disposal)

Parameters	Concentration not a exceed
Ph	5.5 – 9.0
Oil & Grease	10 mg/ l
Suspended solids	100 mg/l
BOD, 3 days, 27^{0} C	30 mg/l

Note

i. For on-shore discharge of effluents, in addition to the standards prescribed above, proper marine out fall has to be provided to achive the individual pollutant concentration level in sea water below their toxicity limits as given below, within a distance of 50 meter from the discharge point, in order to protect the marine aquatic life:

Toxicity Limit

Parameter	Toxicity Limit, MG/L
Chromium, as Cr	0.1
Copper, as Cu	0.05
Cyanide, as Cn	0.005
Fluoride, as F	1.5
Lead, as Pb	0.05
Mercury, as Hg	0.01
Nickel, as Ni	0.1
Zinc, as Zn	0.1

ii. Oil and gas drilling and processing facilities, situated on land and away from saline water sink, amy opt either for disposal of treated water by on-shore disposal or by re-injection in abandoned well, which is allowed only below a depth of 1000 m from the ground level. in case of re-injection in abandoned well the effluent have to comply only with respect to suspended solids and oil and grease at 100 mg/l and 10 mg/l, respectively. For on-shore disposal, the permissible limits are given below.

Limit to various parameters (on-shore)

S. No.	Parameter	On-shore discharge standards (not to exceed)
1	PH	5.5 – 9.0
2	Temperature	40^0 C
3	Suspended Solids	100 mg/l
4	Zinc	2 mg/l
5	BOD at 27^0 C for 3 days	30 mg/l
6	COD	100 mg/l
7	Cholorides	600 mg/l
8	Sulpahtes	1000 mg/l
9	Total Dissolved Solids	2100 mg/l
10	% Sodium	60 mg/l
11	Oil and Grease	10 mg/l
12	Phenolics	1.2 mg/l
13	Cyanides	0.2 mg/l
14	Flourides	1.5 mg/l
15	Sulphides	2.0 mg/l
16	Chromium (hexavalent)	0.1 mg/l
17	Chromium (total)	1.0 mg/l
18	Copper	0.2 mg/l
19	Lead	0.1 mg/l
20	Mercury	0.01 mg/l
21	Nickel	3.0 mg/l

2. Off – shore Facilities

For off-shore discharge of effluents, the oil content of the treated effluent without dilution shall not exceed 40 mg/l for 95% of the observation and shall never exceed 100 mg/l. Three 8-hourly grab samples are required to be collected daily and the average value of oil and grease content of the three samples should comply with these standards.

Guideline for Discharge of Gaseous Emissions

D. G. Sets

DG sets at drill site as well as production station should conform with the norm notified under the Environment (Protection) Act, 1986. (i.e., guidelines mentioned under Sr. No. 22 of this publication).

Elevated / ground flares

- Cold venting of gases never be resorted to and all the gaseous emissions are to be flared.
- All flaring shall be done by elevated flares except where there is any effect on crop production in adjoining areas due to glaring. In such cases, one should adopt ground flaring.
- In case of groundd flare, to minimise effects of flaring, the flare pit at GGS / OCS should ne made of RRC surrounded by a permanent wall (made of refractory brick) of minimum 5 m height, to reduce the radiation and glaring effects in the adjoining areas.
- A green belt of 100m width may be developed around the flare after the refractory wall in case of ground flaring.
- If the ground flaring with provision of green belt is not feasible, enclosed ground flare system should be adopted, and should be designed with proper enclosure height to meet the ground level concentration (GLC) requirement.
- In case of elevated flaring, the minimum stack height shall be 3-m. Height of the stack shall be such that the max. GLC never exceeds the prescribed ambient air quality limit.
- Burning of effluent in the pits should not be carried out at any stage.

Guidelines for Disposal of solid Waste

Disposal of drill cuttings

- The drill cuttings shall be conveyed through a conveyor system to the disposal pit after proper washing.

- The drill cuttings shall (on-shore/ off-shore) shall conform to the guidelines provided by the Ministry of Environment and Forests.

- The secured landfill pit should be covered with a thick layer of local topsoil provided with proper top shape, after drilling operation is over.

Disposal of Drilling Mud

- The unsuable of the drilling mud (of any composition) after reclamation shall be disposed only at a secured land fill site approved by the concerned authority (State Govt. / SPCBS).

- The disposal of mud should be conforming to the guidelines provided by the MOE & Funder the Hazardous Waaste (management and Handling) Rules, 1989.

- No mud (of any composition) shall be disposed offshore. For offshore installation, the unusable portion of the mud shall be brought back to the shore for disposal in a secured landfill.

- Only water-based mud system to be used. However, where oil – based muds are mused, the mud should be properly treated / incinerated, after they become unusable, in a centralized treatment facility. These should be brought to the shore and treated in case of offshore installation.

Production stage solid waste disposal

- The dried sludge from wastewater treatment plant and other solid wastes at production stage shall be disposed in a secured landfill.

- In case oil content in the sludge is high, it shall be properly treated / incienrated and ash should be disposed in a secured landfill.

The eisting standards in India are comparable to the International regulations. In the policy recommendation's every effort has been made to bring the international standards while explaining the environmental management issues in the process of oil and gas exploration. Two cases were coated, one from British Petroleum and second from Canadian Association of Oil Drilling Contractors. In both these cases the methodology adopted, the kind of data collected for regulatory purposes has been incorporated. An extensive compassion has been made between these regulatory measures and the measures adopted by the Central Pollution Control Board India. It has been observed that the regulatory measures in the International context are strictly enforced compared to the Indian scenario. Since ONGC happen to be major player in India by act of Parliament, its operations were taken lightly so far. However, with the entry of new private organizations and international companies, the environmental issues will be taken more seriously. There is a need to strength the regulatory mechanism in India as a part of protecting the environment, biodiversity and sustainable development in the regions of oil and gas exploration in India. It is to be mentioned that this regulatory mechanism must be applied more towards offshore activities.

REFERENCES

1. Anon, " The Oil industry Experience Technology Corporation and capacity Building" contribution to Agenda 21 UNEP / IPIECA, London 1995.

2. Anon, "Oil and Gas Exploration and Production in Aratic and Sub-Aratic Regions" IUCN / E& P forum (1993) Report No. 2, 55 / 184.

3. "Environmental Management Tools – Sustainable Industrial Development" **Industry and Environment** UNEPIE, Paris volume 18, No. – 23, April – September 1995.

4. Anon, " Treatment of Production Water – A Review of Current Performance" E & P forum (July 1989) Report No. 2. 29 / 111.

5. Anon, "Exploration and Production (E & P) Wash Management Guidelines" E & P forum. September 1993, Report No. 2.58 / 196.

6. Anon, "Environmental Management in Oil and Gas Exploration and Prevention: An overview of issues and management approaches" UNEP forum IE 1997.

7. Anon, "Initial Environmental Evaluation Oil Drilling and Gas gathering station Assam." Central Pollution Control Board. 1983.

8. Anon, "Environmental Evaluation of Oil Drilling and Collection Systems A Follow-up / A pursuit" Central Pollution Control Board, New Delhi 1986.

9. Anon, "Satellite Based Study on Damage One to ONGC gas well blowout in Andhra Pradesh" Water Resources and Ecology Group, NRSA, Hyderabad March 1995.

10. Naveen raj, A.K. Saxena, S. Sen, Ramesh Kumar, and R. S. Dinesh, "Treatment and Disposal of Drilling Wastes (on- shore) in partnership with Environment – A Technological overview and vision presented at the "Workshop on Environment Protection Preparedness in Petroleum Industry and Future Challenges", New Delhi, 2000.

11. Draft Guidelines for Disposal of Drilling Cuttings and drilling fluids (Memograph) CPCB, 2000.

12. Jyoti K. Parikh, V. K. Sharma, " Trade and Environment Linkages: A Case Study of India" Upal Ghosh and ManojK. Panda. IGIRD, Mumbai August 1994.

13. Gopal Choudhary, "Environmental Control Concern to Drilling Engineer" Proceedings of Environmental in Oil Industry – A Vision Beyond 2000, June 4-5, 1999.

14. R.P. Singh, C. J. Singh, Sanjeev Kumar, and Dr. Zainuallah, " Impact of Drilling Activity on Environment" Workshops on Environment Protection Preparedness in Petroleum Industry and Future Challenges, March 30-31, 2000 New Delhi.

15. TEDDY, TERI, New Delhi, 1999 / 2000

16. Hidore, J. J. Global Environmental Change: Its Nature and Impact, Upper Saddle River, NJ; Prentice Hall, 1996.

17. Gold, E. Handbook on Marine Pollution, Arendal, Norway: Assuranceforeningen gard, 1985.

18. American Public Health Association (APHA).. Standard mathods for the examination of water and wastewater: 16th Edition, Washington, DC, 1,268 pp., 1999

19. U.S. Coast Guard. Guidelines for natural resource trustees: National Pollution Fund Center, Washington, DC., 1995

20. Stanislav Patin, Envirnmental Impact of the Offshore Oil and Gas Industry., 1999

21. Mastets, C. D., Root, and Attanasi, E. D., World petroleum assessment and analysis: Proceedings of 14 th World Petroleum Congress, p. 529 – 541. 1994

22. Oil and Gas Journal, Oil and gas reserves, oil output rise in 1996: Oil and Gas Journal, v. 94 (December), n.53, p. 37 – 38. 1996

23. Amrican Petroleum Insitute, http://www.api.org/indutry/exploration/epbasicfacts.htm (as on 22/2/2002)

24. APSPCB, www.aspcb.org (as on 20/2/2002)

25. ONGC, www.ongc.net (as on 24/3/2002)

26. CPCB, www.cpcb.delhi.nic.in (as on 24/3/2002)

27. Hudgins, CM., Chemical usage in North Sea Oil and Gas Production and Exploration Operations. Report for the Norwegian Oil Industry Association. Petrotech Consultants Inc, Houston, Texas., 1991

28. Intergovernmental Panel on Climate Change., Climate Change 1995: The Science of Climate Change, Working Group 1 Second Assessment Report, Cambridge University Press., 1995

29. Intergovernmental Panel on Climate Change., Impacts, Adaptions & Mitigations of Climate Change: Scientific – Technical Analysis, Working Group IIIPCC, Cambridge University Press, p 16. 1996

30. World Energy Council., Global Energy Perspectives to 2050 and Beyond., 1995

31. Medows, DH, Meadows, DL and Randers, J., Beyond the Limits, Global Collapse or a Sustainable Future, Earthscan, London, p69., 1992

32. 1993 figure, from International Energy Agency World Energy Outlook 1996

33. NMAC 6.2. "Environmental Protection, Water Quality, Ground and Surface Water Protection," New mexico Water Quality Control Commission., 1996

34. Pontiffet al. "Theory, Design and Operation of an Environmentally Managed Pit System," in Proceedings of the First International, Symposium on Oil and Gas Exploration and Production Wates, New Orleans, Louisiana. Pp. 977 – 986, 1990

35. Webb, W.G. "Vapor Recovery Uses Produced Water," in The American Oil & Gas Reporter, 1993.

36. Jones, V. T., M. D. Matthews, and D. M. Richers, Light hyderocarbons for petroleum and gas prospecting, in M. Hale, ed., Geochemical Remote *Sensing of the Subsurface:* Handbook of Exploration Geochemistry, Vol. 7 (G.J.S Govett, ed.): Elsevier Science B. V., p. 133 – 212., 2000

37. Guidance notes on offshore petroleum production and pipeline assessment of environmental effects and regulations., www.og.dit.gov.uk/regulations/guidance/opp_pipelines/index.html., 1999

38. Jayaraman P.S.et.al (1996) Report on Ambient Air Quality Monitoring around Borhollla **field** DVP Jorhat, IPSEM report, GOA

39. Paul KK et.al (1995) contamination of water pollution *vis-à-vis* Environmental Management in Drilling operations, Ptro-Tech 95, New Delhi, india

40. Kamal Nain, kar M. K, Gupta H.C, Bora P. K and Hazarika S.C( ) **Report on Environmental Pollution Monitoring in Dhansiri Valley,** Project Report ( )

41. Atlas, R.M and Bartha R (1992) Hydrocarbon biodegradation and oil spill bioremediation, Advances in microbial Ecology( )

42. Brady N. C (1990) **The Natural and Properties of Soils,** Macmillan Publishing company, New York

43. Candler, J. E (1992) "Source of Mercury and Candmium in Offshore Drilling Discharges" SPE Drilling Engg. Journal, December

44. Oakley, D. J (1992), "Cooperative Research – A Route to Reduce the Environmental Impact of Drilling Fluids" SPE Drilling engineering Journal, September

45. Steber, J, et al (1994), "Solving fluid biodegradation in sea ed drill cutting pile – Environmental Drilling Fluids" *Offshore Journal,* September

46. Masters G. M (1995). **Introduction to Environmental Engineering and Science,** printice Hall of India Private Limited, New Delhi

47. Anon (1993) **DuPont Chambers Workers Waste Minimization Project,** United States Environmental protection Agency.

48. Anon (1997 – 2000), ONGC Annual Reports, Oil and Natural Gas Corporation, Mumbai.

49. Anon, **Risk Analysis for Bombay High North (BHN)** Engineers India Limited

50. Modak P, **Wast minimization – A Practical Guide to Cleaner Production and Enhanced Profitability,** Centre for Environment Education, Ahmadabad

51. Bhatnagar R. N, **Safety in Indian Petroleum Sector,** KLG – TNO Safety Technologies Limited, New Delhi

52. Das Gupta A. B, **Challenges and Opportunities of the Petroleum Industry in the Next Century**

53. Kapoor S, and Koshel K. C, **Indian Upstream Oil Industry at Cross Roads: Where to go.**

APPENDIX 1

SOCIO ECONOMIC SUREVY OF HOUSEHOLDS
(conducted by the University of Hyderabad)

HOUSEHOLD QUESTIONNAIRE

Location: **Name of the Village:**
Mandal : **District :**

1. Demographic Information

Name of the respondent :

Sex : Male : Female : Age :

Education : None /Primary /Secondary /Above

Occupation : Farmer /Employed / Labour

Income (Rs/year) :

Live stock

Type Number

Land for cultivation (Acres) : Irrigated /Unirregated

Crops grown

Crop Yield (tonnes/crop)

2 **Quality of life in the village**

Literacy rate (%)

Employment opportunities Yes No

Awareness of environment Yes No

Awareness of ONGC operations Yes No

Infrastructural facilities (please tick one)

Good

Alright

Bad

Sanitary conditions (please tick one)

Good

Alright

Bad

Satisfied with the Yes No

Migration to urban areas Yes No

Name of the Drill Site /Productive Site

3 Information Related to Drilling Site and the Respondent

Distance from the nearest drilling site :

Any of the family members employed by ONGC : Yes No

If yes, number of persons employed :

Whether any land given to ONGC Yes No

If yes, how many acres? :

Period (Year) :

Irrigated / unirrigated land :

Compensation received (Rs) :

4. Impact of ONGC drilling

4.1 Eonomic benefits

4.1.1 Direct employment

No.of persons employed

Wages Rs. Per day

Employment days per year

4.1.2 Indirect employment (specify)

No. of personal employed :

Income :

4.2 ***Social benefits*** (please specify)

Better livelihood

Better environment

Improved Infrastructure facilities

4.3 ***Economic costs***

Increase in the price of (Please tick)

Yes No

Land

Goods/commodities
Cost of living

4.4 ***Social costs***

Increase in

Yes No

Crime rate
Purehealth

Were their any leaks and blow out – Yes No

If Yes Impact - Nil /Marginal /Significant

5. Environmental Issues

5.1. Noise

5.1.1 Occurrence of sound problem (number of days)

During the drilling
At production stage

5.1.2 Source of noise pollution

Drilling
Oil pump
Flare stack
Gas separator
Loading Point
Trucks moving

5.1.3. Disorders in the family due to noise Yes No

If yes

Level of hearing impairment Low /Medium /High
Medical expenditure involved for treatment (Rs.)

Effect on live stock Low /Medium /High

5.2 ***Air***

Rise in temperatures (degrees Celsius) :
Feeling of bad smell in the neighborhood Yes No
If yes,

Type of odour (smell) :
If bad odour, Seasonality (Summer/Rainy/Winter) :
Impact on health (specify) Yes No

If Yes, do you have the following symptoms :
Cough /Cold /Breathlessness /Wheezing /Phlum /Headache
How long : Days /Months

No.of man days lost
Expenditure involved in medical treatment (Rs.)
Impact on live stock (specify):
Impact on agriculture (specify) :
Impact on flora and fauna (specify)

5.3 *Water*

5.3.1 Surface water:

Change in temperature (increase/ decrease/no change)
Seepage - (water streams /irrigation canals/ponds/tank)
Impact on Agriculture (yield / diseases)
Impact on drinking water (specify)
Type of contamination (specify)
Taste
Odour
Colour
Florides
Oil /grease
Source of contamination (ONGC/others)
Any human diseases due to water contamination
Seasonal (pre-monsoon / post monsoon / summer)
Change in water levels in the streams (summer/pre-monsoon /post monsoon)\

5.3.2 Ground water

Level of water table (before and after drilling)
Down /same
Depth of Wells (metres)
Changes in the water quality (specify)
Taste
Flavour
Odour
Impact on drinking water (specify)

5.4 ***Soil***

Change in the soil fertility Yes No
If yes, mention the changes
Type of soil near the drilling site
Change in the yield due to ONGC operations Yes No
Change in use of fertilizers/ pesticides (specify)
Change in cropping pattern (Specify)
Change in grazing land (specify)
Loss in cultivation drilling time (specify)

5.5 Irrigation and Livestock

Impact on Irrigation (specify)

Impact on live stock (specify)
Impact on flora & fauna (specify)
Health disorders if any (specify)
No.of mandays lost
Expenses incurred crop/irrigation (specify)
Change in cropping pattern (specify)
Major impacts on irrigation (Specify)
Impact on acquaculture (fish, etc.) -
Impact on live stock (specify)

Date:

Name of Surveyor:

APPENDIX 2

TECHNO – ECONOMIC SUREVY
(University of Hyderabad)
QUESTIONNAIRE

Name of the Drilling Site:
Mandal:
District:

1. **General Information**
   Name of the Respondent
   Educational Qualification
   Designation

2.1 Land Acqisition Details:

Land acquisition (acres) -
Acquisition cost (Rs / acre) -
Type of Land
Barren
Dry
Wet/cultivated
Crops cultivated
Crop Yield/acre (tonnes) Income/acre (Rs)
Local habitat- Forest /Agriculture/ Coconut/groves/Wasteland / Waterbodies

3. Information Related to Drilling site :

3.1 Geographic and Sedimentary formations

Drilling site area -
Temperature -
Pressure -
Reactive shale -

4. Drilling Operations

Duration of Drlling (No. of days/hours per day)
Workers (no) -
Directly on the rig
Support workers
Indirect workers
Amount and Type of fuel used
Diesel
Electricity
Type and quantity of drilling fluid used
Volume of water used (for every meter drilled)

4.1 Details about drilling

Depth of the Well
Waste disposal method -

Cementing used (Qty.) -
Chemical composition -
Number of wells in operation
Number of wells abandoned -
Reasons (specify) -

4.2 Chemicals injected

(a) <u>Type</u> <u>Quantity</u> <u>What stage used</u>

4.3 Drilling mud (waste disposal)

Quantity -
Chemical combinations
(Type / Qty.) **-**
Solids -
Liquids -
Methods of disposal -
Expected environmental damage -

4.4 Effluent Treatment Plant (ETP)

Capacity
Input
Output

5. Production of Oil and Gas

5.1. Group gathering station (GGS) :

Pumped (Qty.) -
water (volume or %) -
gas (volume or %) **-**
oil (volume or %) -
Area of CGS -
Characteristics of crude -
Number of wells connected-
Volume of crude oil handled -
Volume of gas handled -
Pipeline length -
Pipeline size -
Leakage - Type and Qty. -

5.2 Central Tank Farm (CTF) :

Retention time -
Gas flaring - Technical (%) -
- Other (Type %) -
Stack monitoring -

Stack flaring -
Volume of gas flared -
Stack height, Diameter -
Process failure ?

5.3 ETP Treatment plant :

Chemicals used -

<u>Type</u> <u>Qty.</u>

Emulsion subject to chemical treatment -

ETP - Size -

Volume handled -

Characteristics before and after -

Chemicals discharged -

<u>Type</u> <u>Qty.</u>

5.4 Water reinjected (amount)

Water discharged (amount) -

Oil context in water discharged (Volume or %) -

Date :

Name of the Surveyor :

-