ENVIRONMENTAL CONCERNS POSED BY OIL AND GAS INDUSTRY IN INDIA

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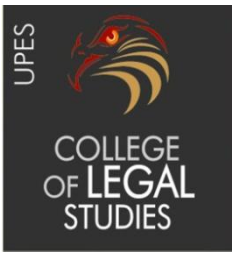
This dissertation is submitted in partial fulfillment of the degree of B.A., LL.B. (Hons.)



College of Legal Studies
University of Petroleum and Energy Studies
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CERTIFICATE

This is to certify that the research work entitled **"ENVIRONMENT CONCERNS POSED BY OIL AND GAS INDUSTRY IN INDIA"** is the work done by **SHIPRA** under my guidance and supervision for the partial fulfillment of the requirement of **B.A., LL.B. (Hons.)** degree at College of Legal Studies, University of Petroleum and Energy Studies, Dehradun.

Signature & Name of Supervisor:

Designation:

Date:

DECLARATION

I declare that the dissertation entitled **"ENVIRONMENTAL CONCERNS POSED BY OIL AND GAS INDUSTRY IN INDIA"** is the outcome of my own work conducted under the supervision of Prof. Tony George, at College of Legal Studies, University of Petroleum and Energy Studies, Dehradun.

I declare that the dissertation comprises only of my original work and due acknowledgement has been made in the text to all other material used.

Signature & Name of Student:

Date:

INDEX

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1. INTRODUCTION

The historical backdrop of oil and gas industry demonstrates that its working surroundings have always been a complex one. All sections of the business (generation, refining, transportation, stockpiling and dispersion) have been changed into global and very competitive. Exploration of energy resources has assumed an essential part in creating and maintaining individual advancement and economic development. The general public's dependence on oil and gas has expanded manifolds in the recent years. The opened up utilization of hydrocarbons has brought about environmental degradation in different ways.

The Oil and Natural Gas ("O&NG") area has enormous development potential in India. It is well-regulated industry and in spite of slowdown in the Indian and global economy, demand for O&NG has been consistent. Generally, O&NG has been the area of Government of India and select government undertakings. With liberalization and privatization, there has been support from private entities, both private and foreign. The exploration of O&NG reserves has not always been without some environmental impact. Oil slicks, damaged terrains, accidents and fires, occurrences of air and water contamination have all been recorded at different time and places. Familiarity with the significance of environmental issues has become more and more central to the thinking of the oil business and regulators in the most last decade.

India is and shall remain extremely dependant on coal for about half of its primary commercial energy needs with the other half being dominated by O&NG put up together. The Indian hydrocarbon industry is, as of now, going through a challenging stage. Growing concern toward energy security, increasingly tough environmental regulations, emergence of natural gas and changing crude oil and natural gas prices have hurled both difficulties and chances to the Indian oil and gas industry.

The base of the country’s energy supply system is tilted towards fossil fuels, which are finite. This has serious long-term implications as the emerging patterns of energy

consumption, which is heavily skewed towards oil and gas, bring to focus many ecological and environmental issues.

Realisation of high economic development aspirations by the nation in the coming decades, calls for swift development of the energy market. The energy resources available indigenously are limited and may not be sufficient over the long run to sustain the process of economic development translating into increased energy import dependence. The base of the nation's energy supply framework is tilted towards fossil fuels, which are limited. This has serious long-term implications as the emerging patterns of energy utilization, which is heavily skewed towards oil and gas, bring to focus many ecological and environmental issues.

2. EVOLUTION OF OIL AND GAS INDUSTRY IN INDIA[1]

2.1 Pre-Independence 1866-1947

2.1.1 In **1886**, Mr. Goodenough of McKillop Stewart Co. drilled a well near Jaypore in Upper Assam and struck oil. By **1882**, the Assam Rail and Trading Company, a company registered in London in **1881**, got the rights for exploration in the same area. In **1889**, first commercial discovery of crude oil in the country took place at Digboi. In **1893**, rights were granted to Assam Oil Syndicate which erected a small refinery at Margharita. In **1899**, Assam Oil Company was formed headquartered at Digboi to take over petroleum interests and rights from AOS. In **1901**, first refinery was set up in Digboi.

2.1.2 In **1921**, UK based Burmah Oil Company bought all the shares from ARTC and was appointed commercial and technical managers of AOC. By **1931**, exploration activities were spread all over the Assam-Arakan region. Oilfields were discovered in other regions for which BOC provided technical know-how, financial backing and managerial support.

2.2 1947- 1960

2.2.1 Government of India realized the importance of oil and gas industry and consequently while framing the Industrial Policy Statement of **1948**, the development of petroleum industry in the country was given top priority. In **1953**, first oil discovery of independent India was made at Naharkotiya in Digboi. In **1955**, Oil and Natural Gas Directorate was set up as a subordinate office under the then Ministry of Natural Resources and Scientific Research. In **1956**, the Directorate was raised to the status of a commission with enhanced powers, although it continued to be under the government. In **1959**, Oil India Private Ltd. was incorporated in February for the purpose of development and production of newly discovered oilfields and speed up the pace of exploration in North-East India. AOC/BOC owned two-thirds of share and GoI, one third in it. In

[1] Available at <http://petrofed.winwinhosting.net/upload/Part3.pdf>. Last accessed on 10/03/2015.

October **1959**, ONGC was converted into a statutory body by an act of Parliament. The main functions of ONGC subject to the provisions of the Act were *"to plan, promote, organize and implement programmes for development of Petroleum Resources and the production and sale of petroleum and petroleum products produced by it, and to perform such other functions as the central Government may, from time to time, assign to it."*

2.3 1961-1991

2.3.1 In July **1961**, the Government of India and BOC transformed OIL into a Joint Venture with equal partnership. ONGC's exploratory activities were also spread out to Bihar, UP, Tamil Nadu, Rajasthan, J&K, Kutch and Andhra Pradesh. In **1962**, offshore exploration was initiated in the Gulf of Cambay. In **1972-1974**, exploratory activities were taken up in Bombay Offshore leading to India's biggest commercial discovery the Bombay High, now known as Mumbai High, thereby establishing a new hydrocarbon province. ONGC Videsh Limited (OVL) was formed with a view to undertake the overseas exploration and production activities on behalf of ONGC. In **1981**, OIL became a wholly owned GoI enterprise by taking over BOC's 50% equity and the management of Digboi oilfields changed hands from erstwhile AOC to OIL.

2.4 Post 1991

2.4.1 The economy was liberalized by the GoI following which core sectors (including petroleum) were deregulated and de-licensed. As a result of this economic policy, ONGC was reorganized in February **1994** as a limited company under the Companies Act. In **1995**, Sundarajan Committee submitted its report on restructuring and devising strategies to meet challenges of the new economic environment. This report favoured de-regulation of petroleum industry at one stroke. But the Strategic Planning Group on Restructuring of Indian Oil Industry decided it should be done in a phased manner. In **1993**, Director General of Hydrocarbons was set up by a Government Resolution to which certain advisory regulatory roles were entrusted but no development role was assigned.

2.4.2 In **1997**, the GoI, in order to accelerate pace of exploration efforts in the country, approved the New Exploration Licensing Policy by providing a number of attractive fiscal and contractual terms. In **1998**, NELP launched and 48 exploration blocks offered under round-I.[2] Till **2000-2014**, 10 rounds of NELP have been held and various exploration blocks have been awarded. Also, four rounds of bidding of CBM (Coal Bed Methane) blocks have been held till **2010** and various CBM blocks have been awarded under the same.[3]

[2] Available at <http://www.dghindia.org/EandPGovernanceInIndia.aspx>. Last visited on 16/03/2015.
[3] Ibid

2. ENVIRONMENTAL CONCERNS OF OIL AND GAS INDUSTRY: CAUSES AND EFFECTS

Humankind has always been in need of a variety of energy resources for the advancement of civilization and making life more comfortable. Exploration of energy resources has assumed a critical part in generating and sustaining individual development and economic development. The society's reliance on oil and gas has been expanding at a alarming rate. This increased utilization required the exploration, production, development and transportation of hydrocarbons. The results of increased use of these hydrocarbons bring about environmental degradation in many forms.[4]

Hydrocarbons came from remains of the bodies of prehistoric land based animals, marine organisms and vegetation, which were washed away and buried below the earth during upheavals on the earth's surface millions of years ago. In the course of time, the buried organic matter decomposed and the carbon and hydrogen present in these reacted under the heat and pressure to form various compounds, generally hydrocarbons. The hydrocarbons got trapped in the porous rocks and were covered by hard sedimentary rocks that formed over it. They act as 'cap or 'seal' to prevent hydrocarbons from escaping.[5]

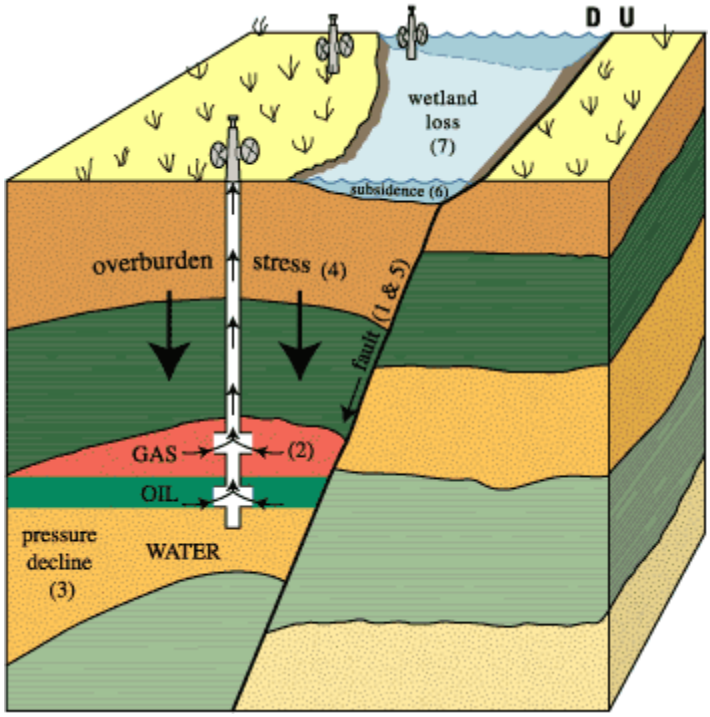
Hydrocarbons in petroleum could be in[6]:

a) *Gaseous Form*: as natural gas, this can be associated with oil in an oil field or found free of oil in a gas field.

b) *Liquid form*: as crude (dark and viscous), or condensate (clear and volatile like motor gasoline).

c) *Solid/Semi-solid form*: as asphalt or tar.

[4] Available at < http://irade.org/eerc/pdf/IPP_FR_Madduri.pdf>. Last accessed on 28/03/2015.
[5] Available at < http://www.petroleum.dmitre.sa.gov.au/__data/assets/pdf_file/0005/58226/pgsa_vol2_2nd_10.pdf>. Last accessed on 28/03/2015.
[6] Ibid



Hydrocarbon formation within the Earth's crust.[7]

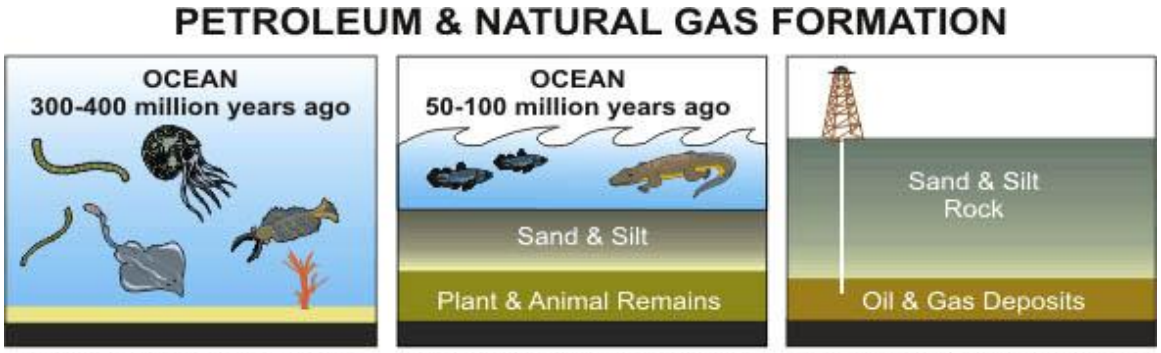
Crude Oil: Crude oil is a mixture of about 500 organic chemicals, predominantly hydrocarbons (molecules made of carbons and hydrogen). It is recovered from underground reservoirs, normally 1000-5000 meters down the earth. Crude oil can be of wide variety and characteristics. The colour could be black, brown, amber or light brown. It is also called as **Petroleum.**[8]

Natural Gas: Natural gas is a mixture of the lightest hydrocarbons like methane, ethane, propane, butane. It also contains water to its saturation limit. It may also contain hydrogen sulphide**,** carbon dioxide, nitrogen and occasionally small amounts of helium.[9]

[7]Source: Available at <http://pubs.usgs.gov/fs/fs091-01/images/fig1-large.gif.> Last visited on 01/04/2015.

[8] Supra; Note 4 at page 10
[9] Ibid

When natural gas comes out of the well along with crude oil, it is called **associated gas**. Associated gas is produced along with crude in a field which is essentially an oil producing field. When the well produces mainly gas with very little liquids, it is called **free gas.** Free gas production can be shut when we do not want it.



[10]

Various forms of Natural Gas[11]:

a) **NGL:** During production or transportation of gas, the heavy components such as pentane or hexane, condense due to natural cooling and separate out as liquids. This is called NGL (Natural Gas Liquids).This is not really a gaseous component, but volatile liquid.

b) **LPG:** The propane/ butane component of the natural gas is liquefied under moderate pressures and is supplied as cooking gas fuel. This is called LPG (Liquefied Petroleum Gas).

c) **LNG:** Natural gas in bulk is liquefied under very low temperature for transportation in large quantities by marine tankers. This is bulk of the natural gas in liquefied form and is re-vaporized after receiving it at its destination from tankers, to be used as natural gas. The objective of converting the gas to LNG is

[10] Source: Available at <http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/oil.html>.Last visited on 01/04/2015.
[11] Supra; Note 4 at page 11

transportation in large quantities or export by marine tankers. This is called LNG (Liquefied Natural Gas).

d) **CNG:** Natural gas is compressed to high pressures for use as automotive fuel or for transportation in small quantities. This is natural gas in highly compressed form but not liquefied. It is called CNG (Compressed Natural Gas).

The fluid that comes out of the well in an oilfield or gas field is called **well fluid.** It is a mixture of crude oil, natural gas and saline water along with small amounts of sand and sludge. The water which comes out with well fluid is called **formation water or produced water**.[12] *It is important to note here that If the crude oil had been just made of hydrocarbons, processing to get the final products would have been easy and at low cost. But a number of undesirable components come out with the well fluid, which increases the processing blocks and processing cost.* Other components like **sulfur compounds, carbon dioxide, nitrogen, traces of metals** are also present. Their removal constitutes part of processing. **Proportion of oil, water and gas** may vary widely from one field to other. It changes substantially with time during production. Normally, well fluid comes out on its own pressure, which depletes with time. **Artificial methods** of recovery are used in later stages of production.

3.1 Exploration for Oil and Gas:

A commonly used terminology in oil companies, Exploration & Production (E&P), comprises of search, discovery and production of oil and gas by undertaking the following activities:

- **Licensing and agreement**:

  The first step in exploration of oil obviously is entering into contract, lease agreement or obtaining licenses from the governments. Normally the government of the country carries out a lot of surveys (see next item) to define a **'block'** for

[12]Available at < https://www.usbr.gov/research/AWT/reportpdfs/report157.pdf>. Last accessed on 29/03/2015.

exploration and invites bids. The selected bidder then enters into agreement with the government. There are two types of arrangements:

A) Licenses to the exploring company to explore and produce oil and gas with license fees, royalties (per unit production) and taxes payable to the state.

B) Production sharing contracts, in which the state or a state owned company, is made a partner in the venture. Normally the initial exploration costs are borne by the licensee. Revenues earned on production are first set-off against the costs incurred by the licensee and the balance amount is shared in an agreed percentage.

Once the agreement is reached, the exploration starts.

- **Geological surveys** and **Geophysical surveys**

Geologists try to develop a model or a map where hydrocarbon might occur, based on geological principles. The map is based on a wide variety of geological information. They try to locate anticlines and domes by mapping rock layers coming out of earth's surface. They use very conventional tools like hand-held compass, telescope etc. to determine the orientation of the rock layers. With these instruments geologists generate drawings and maps of the position and size of the rock protrusions.

When exploratory wells are drilled, geologists examine the rock samples and other well data to make subsurface maps of the reservoir rocks. Matching up rock layers between wells allows geologists to draw cross sections in order to find petroleum traps.

Geophysicists measure the properties and patterns of sub-surface rock strata by three types of surveys:

- **Magnetic Survey** - to determine the strength of the Earth's magnetic field at a specific location. It depends upon measuring the variations in intensity of the magnetic field which reflects the magnetic character of the various rocks present.
- **Gravity Survey** - to determine the strength of the Earth's gravity at a location. It involves the measurements of small variations in the gravitational field at the surface of the Earth.
- **Seismic Survey** - to draw subsurface maps using sound waves. In seismic survey explosive charges are detonated in holes drilled by truck mounted rigs at specific points in the survey area. This rig is called **Thumper Truck**. It relies on the differing reflective properties of sound waves to various to various rock strata, beneath terrestrial or oceanic surfaces. An energy source transmits a pulse of acoustic energy into the ground which travels as a wave into the Earth. At each point, where different geological strata exist, a part of the energy is transmitted down to the deeper layers within the Earth, while the remainder is reflected back to the surface. Here it is picked by a series of sensitive receivers called geophones or seismometers on land, or hydrophones submerged in water.

  Special cables transmit the electrical signals received to a mobile laboratory, where they are amplified and filtered and then digitized and recorded on magnetic tapes for interpretation.

  Dynamite was once widely used as the energy source, but environmental considerations now generally favour lower-energy sources such as vibroseis on land[13] and the air gun in offshore exploration. In areas where preservation of vegetation cover is important, the shot whole method is preferable to vibroseis.

[13] A generator that hydraulically transmits vibrations into the earth.

- **Interpretation of data** and **geological modeling**

  The data collected based on geophysical and geological observation is analysed and interpreted and on the basis of that geomodelling is done. Geological Modelling or geomodelling is the science of creating computerized representations of portions of the Earth's crust.[14] It is useful for predicting the behavior of rocks under various hydrocarbon recovering scenarios.

- **Identifying hydrocarbon resources** and their location based on the interpreted data.
- **Economic evaluation** of the located reserves.
- **Exploratory drilling**

  Once a geological structure has been identifies the only way to confirm presence of hydrocarbons and the thickness and internal pressure of a reservoir is to drill exploratory boreholes. The wells that are drilled to discover hydrocarbons are called 'exploration wells'.

- Preparation of **field development plan**.
- **Commercially exploiting** them by setting up necessary drilling and production infrastructure.

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

[14] Available at < http://www.encyclo.co.uk/meaning-of-Geomodeling>. Last accessed on 27/03/2015.

runs into crores of rupees and if succeeds, the return are also huge. If the results are negative at any stage, the activity is abandoned at that stage.[15]

3.2 Oil and Its Growing Importance:

The oil and gas industry is one of the six core industries in India. It is of strategic importance and plays a pivotal role in influencing decisions across other important spheres of the economy.[16]

In 1997-98, NELP was envisioned to deal with the ever-growing gap between demand and supply of gas in India. As per a recent report, the oil and gas industry in India is anticipated to be worth US$ 139,814.7 million by 2015. With India's economic growth closely linked to energy demand, the need for oil and gas is projected to grow further, rendering the sector a fertile ground for investment.[17]

3.3 Statistics[18]:

- Demand for primary energy in India is to increase threefold by 2035 to 1,516 Million Tonnes of Oil Equivalent from 563 Million Tonnes of Oil Equivalent in 2012.
- Oil imports constitute over 80% of India's total domestic oil consumption as of may, 2014.
- Oil and Gas contribute 39.2% to primary energy consumption.
- During 2013-2014, natural gas constituted about 7.8% of India's energy mix.
- India had 47 trillion cubic feet of proven natural gas reserves at the beginning of 2014.
- Approximately 34% of total reserves are located onshore, while 66% are offshore.

[15] Supra; Note 4 at page 11
[16] Available at < http://indiainbusiness.nic.in/newdesign/index.php?param=industryservices_landing/345/1>. Last accessed on 23/03/2015.
[17] Available at < http://www.ibef.org/industry/oil-gas-india.aspx>. Last accessed on 23/03/2015.
[18] Available at < http://makeinindia.com/sector/oil-and-gas/>. Last accessed on 23/03/2015.

- Investments worth USD 70 billion are expected across the oil and gas value chain during 2012-2017.
- At the end of 2013, India had 215.066 MMTPA of refining capacity, making it the second largest refiner in Asia after China. Private joint venture companies own about 41% of total capacity.
- India increasingly relies on imported LNG; the country was the fourth-largest LNG importer in 2013 and accounted for 5.5% of global imports.
- India's crude oil pipeline network spans just under 9460 miles and has total capacity of 129.4 MMTPA.
- India held nearly 800 MMT of proven oil reserves at the beginning of 2014, mostly in the western part of the country.
- About 44% of reserves are onshore resources, while 56% are offshore. The country's natural gas pipeline network amounted to over 15, 340 kms in 2013 and a proposed expansion of 30,000 kms is envisaged by 2018-2019.
- The government has decided to set up strategic storge of 5.03 MMT of crude oil at 3 locations- Vishakhapatnam, Mangalore and Padur.
- The government has unveiled plans to add another 91 million barrels to its crude oil capacity to protect India from supply disruptions by 2017.
- India projects an increase of the country's refining capacity to 307.366 MMTPA by 2017 based its current Five-Year Plan (2012-2017) to meet rising domestic and export markets.
- In recent years, major discoveries in the Barmer basin in Rajasthan and offshore Krishna-Godavari basin by smaller companies such as the Gujarat State Petroleum Corporation and Andhra Pradesh Gas Infrastructure Corporation hold some potential to diversify the country's production.

By 2015-2016 India's demand for gas is set to touch 124 MTPA against a domestic supply of 33 MTPA and higher imports of 47.2 MTPA leaving a shortage of 44 MTPA, as per projections of Ministry of Petroleum and Natural Gas of India. Moreover, Business

Monitor Index predicts that India will account for 12.4 per cent of Asia-Pacific regional oil demand by 2015.[19]

To cater to the increasing demand, the Government of India has adopted several policies; including allowing 100 per cent foreign direct investment (FDI) in many segments of the sector, such as natural gas, petroleum products and refineries, among others. The government's participation has made the oil and gas sector in the country a better target of investment. Today it attracts both domestic and foreign investment. The major players in the oil and gas industry in India today are: ONGC, IOCL, OIL, HPCL, BPCL, GAIL etc. (government/national oil companies) and Reliance Industries Limited, Cairn Energy, Petronet LNG Limited., Essar Oil etc. (private/foreign companies).[20]

3.4 Causes and Effects of Environmental Pollution by Oil and Gas Industry

Petroleum generally, occurs in sedimentary deposits in a complex mixture of hydrocarbons, which exists under the ground or in deep sea. As used in petroleum, extraction of natural gas is extracted with the same type of technology. 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. Some cause and its impacts are analysed below:

3.4.1 Oil Industry and Air Emissions[21]:

The majority of air emissions are from production side due to controlled flaring[22] and venting[23] which are necessary for safe operations. Sometimes accidental discharge from

[19] Supra; Note 14 at page 17
[20] Supra; Note 20
[21] Available at < http://irade.org/eerc/pdf/IPP_FR_Madduri.pdf>. Last accessed on 23/03/2015.
[22] Flaring is the burning of natural gas that cannot be processed or sold. Flaring disposes of the gas while releasing emissions into the atmosphere.

well during blowout/fire emits large amount of gases such as carbon monoxide, sulphur dioxide, hydrogen sulphide etc. containing partially burnt hydrocarbon and metal. All of these are potentially hazardous to human health and vegetation growth. Both onshore and offshore oil exploration activities constitute an important source of emissions.

- 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[24] losses

3.4.2 Effect of Emissions[25]

Volatile Organic Compounds: The principle effect of VOCs is their local ambient ozone. 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 warming potential, which is second only to that of carbon dioxide.

Sulphur oxides (Sox): Sulphur oxides lead to acidic 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 petrochemical smog, particularly where there is no air dispersion. Inhalation of NO and NO_2 can affect respiratory system directly.

[23] Venting is the controlled release of gases into the atmosphere in the course oil and gas production operations. These gases might be natural gas or other hydrocarbon vapors, water vapor, and other gases, such as carbon dioxide, separated in the processing of oil or natural gas.
[24] Fugitive gas emissions are emissions of gases or vapors from pressurized equipment due to leaks and other unintended or irregular releases of gases, mostly from industrial activities.
[25] Available at < http://bellona.no/assets/fil_Chapter_3._Environmental_risks_when_extracting_and_exporting_oil_and_gas.pdf>. Last accessed on 28/03/2015.

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. Contamination in soil can leach into ground water and thereby pollute potable sources. Some of these are toxic to aquatic life.

3.4.3 Oil Industry and Noise[26]

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 upon how close to the source they are. During seismic surveys, underwater explosions are created with air guns. This has particularly disturbing effect on cetaceans[27] which use sound for communication and navigation. Fish are also displaced which in turn affects birds that feed on them. The blasts can damage tissues, lungs, ears in mammals and swim bladders in fish.

3.4.4 Oil Industry and Hydrological Impacts[28]

Aquatic ecosystems are a major concern from the pollution arising out of oil and natural gas production, as it involves various activities that affect the normal functioning of water ecosystems. 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 wetlands communities are also susceptible to

[26] Supra; Note 21 at page 21
[27] A whale, dolphin or porpoise
[28] Supra; note 21 at page 21

pollution arising from the various activities related to petrol exploration. The principal aqueous waste streams from oil and gas operations are:

- Produced Water[29]
- 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 introduction of fill material into surface water permafrost
- Direct and indirect impacts to water supplies by clearing of vegetation
- Disruptions to surface water movements and change 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 areas and the waste products produced during these operations may pose problems in their disposal.

3.4.5 Impacts on Soil Ecosystem[30]

Potential impacts on soil arise from three basic sources: physical disturbance as a result of construction; contamination resulting from spillage and leakage or solid waste

[29] Produced water is water trapped in underground formations that is brought to the surface along with oil or gas. It is by far the largest volume byproduct or waste stream associated with oil and gas production.
[30] Supra; Note 21 at page 21

disposal; and indirect impact arising from opening access and social change. The extent on any 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:

a) Compaction[31]
b) Contamination from various operational discharges
c) Changes in the drainage pattern
d) Erosion resulting in change in the landscape and pooling of water

3.4.6 Impacts on Biodiversity[32]

Flora

Loss of flora 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, and reduces the availability of habitat for wildlife. Vegetation can also be lost 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

[31] Compaction is the process of applying energy loose soil to consolidate it and remove any voids, thereby increasing its density and consequently its load-bearing capacity.
[32] Available at < http://www.ipieca.org/event/20100318/impact-assessment-biodiversity-and-extractive-industries>. Last accessed on 28/03/2015.

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 loss 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.

4. OIL AND GAS INDUSTRY AND OIL SPILLS: AN OVERVIEW[33]

Marine pollution is the most common form of pollution created by oil and gas industry. Shipping is the most common form of carrying cargo. **Oil spills are the prominent cause of marine pollution**. This not only affects the marine life but also of the people who live along the coast whose livelihood depends on fish and other fauna related to marine ecosystem. Some of the **causes of marine pollution** are as follows:

- **Natural seepage from Seabed[34]**

  Seepage can occur either through fault zone extending to the seabed, or the absence of an impervious cap rock. Seepage from shallow oil sources below the seabed can also contribute to leak of oil into the sea. Most of the total oil coming to the sea surface is through these natural seepages, which sometimes appear on the shore as tar balls in certain sea conditions.

- **Ship-borne[35]**

  All sea going marine craft, including drilling rigs, are required to comply with various International maritime Organization (IMO) conventions as well as the International Convention for the Prevention of Marine Pollution from ships Convention 1973 as modified by the Protocol of 1978 (MARPOL 73/78) requirements. With full compliance of the pollution control requirements of MARPOL 73/78, there should be no incidence of oil spill. Pollution continues to take place, however, from both ships and drilling units. There are three broad categories:

  a) **Operational:** Operational spills may occur due to the malfunction of oil water separators and other shipboard systems. Such events are infrequent, as all ships are periodically inspected; maintain a log, recording all operations involving the transfer of oil.

[33] Available at < http://www.psa.gov.in/sites/default/files/11913308371_File1_ROAD_MAP.pdf>. Last accessed on 30/03/2015.
[34] Ibid
[35] Ibid

b) **Contravention of Conventions and Legislations:** These are deliberate actions, and occur mainly when oil tankers in ballast discharge tank washings out on the open sea in the Arabian Sea or the Bay of Bengal, uncomfortably near Indian coasts. These pollutants eventually reach the Indian coast and cause most of the visible pollution on beaches.

c) **Accidental:** These are the result of ship collisions, structural failure of cargo tanks, or ship groundings. Such events can generate catastrophic quantities of oil spill. Though these risks are now minimized on modern tankers, which are required to have double hull nevertheless, accidents do happen releasing enormous quantities of oil and endangering the marine environment.

- **Upstream Exploration and Production[36]:** All world-class operators maintain high standards of safety and operational efficiency. The design of equipment and training of operators ensures that risk of accidental spills is minimized. During operations, minor spills may occur due to valve or equipment leakages. Major spills may occur in the event of blowouts, failures or structures/equipment or rupture of risers and pipelines. All crude oil contains a large percentage of persistent oil fractions, which are the cause of serious oil spill situations. A range of service vessels and equipment can also create pollution. All marine craft are required to comply with the IMO and MARPOL conventions; the E&P operator is responsible for ensuring compliance.

- **Transfer to Downstream[37]:** The oil produced from offshore wells is processed on platforms or Floating Production Storage Offshore (FPSO). After processing, the crude oil (and associated gas) is transferred to shore terminals and refineries. This is done through various means: (a) *direct transfers by trunk pipeline[38] to shore after aggregation from a group of wells,* (b) *pumping the produced oil to*

[36] Supra; Note 29 at page 26
[37] Ibid
[38] A main supply channel for oil and gas

single point mooring(SPMs)[39] *which can berth large tankers for transfer of oil to a shore refinery;* (c) *ship to ship operations from storage vessels to daughter ships,* (d) *use of FPSOs*

All these operations transfer oil with hoses and other portable equipment- a possible risk of accidental oil leakage. Strict adherence to international codes for equipment and practices such as those prescribed by the Oil Companies International Marine Forum (OCIMF) minimizes such risks.

- **Ports and Terminals**[40]**:** In India there are twelve major ports which come under the administrative control of the Central Government (Ministry of Shipping). A large number of minor ports are governed by the Indian Ports Act, 1908 but administered by State Governments. In the case of major ports, centralized policies are set-out by the Ministry of Shipping (MoS); additionally, each port has its own byelaws. As India is a signatory to the Oil Pollution Prevention Conventions (OPRC), certain minimum facilities and equipment are, therefore, required to be maintained at ports to deal with operational and accidental oil leakages as well as to receive contaminated ballast from tankers. The setting-up of ballast reception facilities has not so far progressed due to the high capital cost involved as well as the absence of any enforcing legislation. Convention requirements and local regulations prohibit the release of pollutants within territorial waters or regions adjoining the ports. Minor spills may take place during the course of port operations; in most cases, these are due to contraventions of the regulations. Accidents such as collisions between ships or groundings in port or navigation channels may lead to major spills.

[39] A single point mooring is a floating buoy/jetty anchored offshore to allow handling of liquid cargo such as petroleum products for tanker ships. SPM is mainly used in areas where a dedicated facility for loading or unloading liquid cargo is not available.
[40] Supra; Note 29 at page 26

- **Near Coast Refineries and Processing Plants[41]:** This will include all industries located on the Indian coast such as refineries, chemical and petrochemical plants dealing with a wide range of hydrocarbons and other derivative chemicals. The Oil Industry Safety Directorate (OISD) and the national regulatory bodies prescribe regulations and guideline for the design, construction and operations of such industrial plants. Barring accidents and other exceptional events, there is little risk of operational leakages to the marine environment from well-managed processing plants.

4.1 Impact of Oil Spill[42]

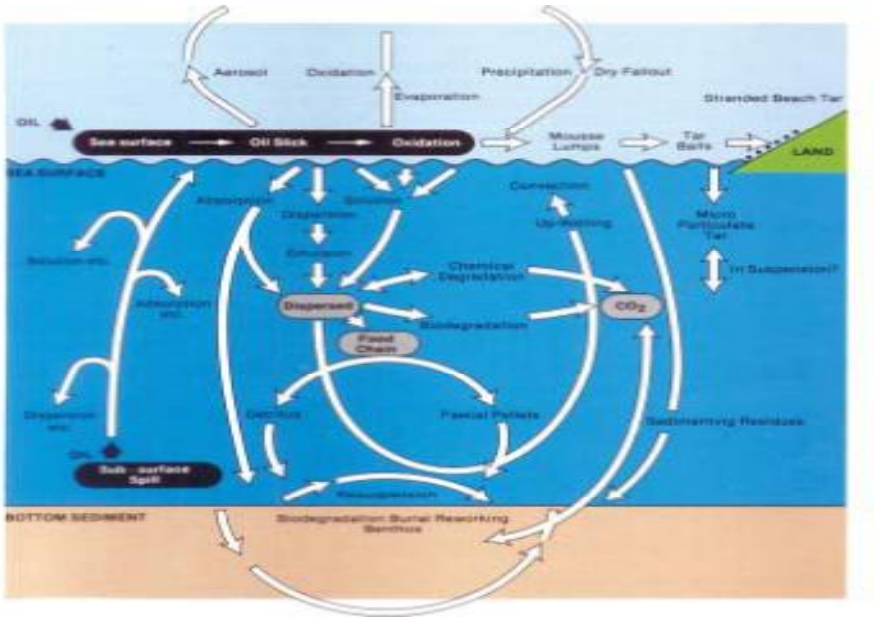
The seriousness of spills varies with the amount, the type of oil, and location. Visible signs of a spill generally vanish in a relatively short time, but local plants and animals may be hurt, and the diversity of species is sometimes affected.

Spilled crude and other oil products may affect organisms both- directly and indirectly- through habitat impacts, food-chain disruption and alteration to their community. The magnitude of the impact varies depending on the type of product spilled, the climate and the flow dynamics of the system receiving the spill, and the response measures taken. Since oil is compromised of hydrocarbons- essentially the remains of ancient organisms- the moment it is spilled into water it begins to weather and degrade. Weathering is a natural process that breaks down the oil through physical and chemical changes: spreading, evaporation, dispersion, emulsification, biodegradation, dissolution, oxidation, and sedimentation.

Spills close to the shoreline tend to have the greatest immediate impact because more diverse forms of life may come into contact with the oil. In addition to ecological concerns, shoreline spills can affect the air quality, due to the hydrocarbon gases and sulphur compounds present in the oil, and are also a potential fire hazard. They will also

[41] Supra; Note 29 at page 26
[42] Ibid

depress recreational areas, harbors, industries, commercial fishing grounds and tourist attractions.



The rate at which oil spills spread will determine the effect on the environment. Most oils tend to spread horizontally into a smooth and slippery surface, called a slick, on top of the water. Factors which affect the ability of oil to spread include tension, specific gravity and viscosity.

The severity of the impact of an oil spill depends on several factors, including characteristics of the oil itself. Natural conditions, water temperature, weather and wind conditions also influence the behavior of oil in aquatic environment. Various types of habitats have differing sensitivities to oil spills.

Some lighter substances in the oil spill may evaporate quickly. Therefore, plant, animal, and human exposure to the most toxic substance is reduced with time, and usually limited to the initial spill area. Although some organisms may be seriously injured or killed very soon after contact with the oil in a spill, non-lethal toxic effects can be more subtle and often long lasting. For example, aquatic life reefs and shorelines are at risk of being

smothered by oil that washes ashore. It can also be poisoned slowly by long-term exposure to oil trapped in shallow waters on beaches.

4.2 Effect of Oil on Marine Organisms[43]

The extent of damage caused by an oil spill depends upon the quantity of the oil spilled, the type of oil, and the prevailing oceanographic and meteorological conditions there.

When oil spills in a large quantity it temporarily affects the air-sea interaction, thus preventing the entry of oxygen from the atmosphere. The first set of organisms to be affected is the primary producers, such as phytoplankton[44]which is the base of the marine food chain. Other free swimming organisms such as fish larvae, and fish, are also affected. When they come in contact with the oil, the gills of the fish are clogged by the oil, which prevents their breathing and kills them. If the oil spill occurs in an enclosed area and the surface remains undisturbed by winds and other oceanographic conditions, the water below becomes deoxygenated due to the absence of air-sea interaction. This causes the mass mortality of inhabiting organisms due to lack of oxygen for respiration. Furthermore, when oil eventually sinks, it affects the benthic[45] organisms such as clams and mussels, as tar particles are deposited in the mantle of these organisms, arresting their physiological activities including respiration.

Spilled oil can also damage parts of the food chain, including human food resources. Aquatic environments are made of complex interrelations between plant and animal species and their physical environment. Harm to the physical environment will often affect one or more species in a food chain. The effect an oil spill is likely to have on an organism is dependent on the coastal environment in which the organism spends most of its life, for example in open water, near coastal areas, or on the shoreline. In case of fire the organisms are killed by high temperatures and burning gases.

[43] Available at < http://www.epa.gov/OEM/docs/oil/edu/oilspill_book/chap1.pdf>. Last accessed on 30/03/2015.

[44] Phytoplanktons are the autotrophic components of the plankton community and a key factor of the oceans, seas and freshwater basins ecosystems.

[45] Benthos is the community of organisms which live, on, in, or near the seabed, also known as benthic zone.

In open water, fish and whales have the ability to swim away from a spill by going deeper in the water or further out to sea, reducing the likelihood of their being harmed even by a major spill. Aquatic animals that generally live closer to shore, such as turtles, seals and dolphins, risk contamination by oil that washes on to beaches or by consuming oil contaminated prey. In shallow waters, oil may harm sea grasses and kelp beds, which are used for food, shelter, and nesting sites by different species. The most affected are the submerged and sessile organisms inhabiting the inter-tidal areas. Both of these have the richest biodiversity and density in any given area.

Spilled oil and cleaning operations can also threaten different types of aquatic habitats. Some of them are as follows:

- Coral reefs are important nurseries for shrimps, fish and other animals as well as recreations attractions for divers. Coral reefs are important nurseries for shrimps, fish and other animals as well as recreational attractions for divers. Coral reefs and the aquatic organisms that live within and around them are at risk from exposure to the toxic substances in oil as well as smothering.
- Exposed sandy, gravel or pebble beaches are usually cleaned by manual techniques. Although oil can soak into sand and gravel, only a very few organisms live full-time in this habitat, so the risk to animal life or the food chain is far less compared to tidal flats, for instance.
- Sheltered beaches have very little wave action to encourage natural dispersion. If timely cleaning is not done, oil may remain stranded on these beaches for years.
- Tidal flats are broad, low-tide zones, usually containing rich plant, animal and bird communities. Deposited oil may seep into the muddy bottoms of these flats, creating potentially harmful effects on the ecology of the area.
- Salt marshes are found in sheltered waters in cold and temperate areas. They host a variety of plant, bird, and mammal life. Marsh vegetations, especially their root systems, are easily damaged by fresh light oils. Mangrove forests are located in tropical regions and are home to diverse plant and animal life. Mangrove trees have long roots, called prop roots, which stick out well above the water level to hold the mangrove tree in place. A coating oil on these prop roots can be fatal to

the mangrove tree and, because they grow so slowly so slowly, replacing a mangrove tree may take decades.

- Marshes and swamps, with little water movement, are likely to incur more severe impacts than flowing water. In calm water conditions, the affected habitat may take restore.
- Other standing water bodies, such as inland lakes, and backwaters are home to a variety of birds, mammals and fish. The human food chain can be adversely affected by spills in these environments.

4. 3 Effects of Oil on Birds[46]

- Contact with crude oil causes their feathers to collapse and mat together. This severely hampers the ability of the bird to fly.
- There is a breakdown in thermal insulation- oiled birds often suffer from hypothermia.
- Crude oil can also cause severe irritation of the skin.
- Birds often ingest the toxic crude oil in an attempt to preen themselves. They may also ingest oil via their prey if their food chain becomes contaminated. The consumption of oil poisons the birds.

In addition to above there may be small, yet, unknown but important, changes which may affect the sea and aquatic life. Therefore, it is even important to initiate combat measures immediately.

4.4 Other Effects[47]:

Besides a deleterious impact on marine ecology and the lives of fishermen, oil spills cause operational problems to several coastal industries as well as shipping. A few examples are given below:

[46] Supra; Note 29 at page 26.
[47] Ibid

A) Atomic Power Plants:

Normally, water for cooling systems is taken at a sub-surface level from the sea adjoining the plant. Whenever the oil floating on the surface is taken below the surface by wave action, there is a possibility that oil contaminated seawater enters the cooling water system, thereby somewhat reducing the heat transfer in steam condensers and heat exchangers causing reduction in power generation during the period. Furthermore, dilution of liquid radioactive waste may be affected by any oil spill, which may increase concentration.

B) Thermal Power Plants:

The seawater used in cooling systems, if contaminated with oil, will affect heat transfer condensers and soft water coolers, which in turn affects the condenser vacuum. This may cause a reduction in generation of power and increased fuel consumption. Furthermore, oil spill may cause choking in rotating screens and filters in cooling water systems leading to disruption of whole working system.

C) Shipping Industry:

Ships and tankers experience the following difficulties:

a) Seawater cooling systems of shallow draft vessels will be fouled up by oil. Deep drafted vessels may change over to lower sea suction.

b) Fresh water generation has to be stopped when navigating in oil-polluted waters. If the oil spill does not clear away, stationary rigs may face fresh water problems. Fresh water making plants are operational in oil polluted waters; therefore, the operation of the stationary unit will be stopped and personal removed. Moving craft will have to navigate in safer unpolluted waters.

c) All ballasting operations have to be stopped; otherwise a clean ballast tank may be contaminated, with the risk of oil pollution during de-ballasting operations. On all vessels, sea water is used as a cooling and fire extinguishing medium. An oil spill combined with a fire caused by the gases emanating from the oil spill cannot be effectively controlled or extinguished. Thus, the hazards to life and property at sea are increased in geometric proportions.

D) Fire Hazard:

There is a potential danger of fire when lighter fractions of oil are evaporating. The dispersion of hydrocarbon gas/air mixture is inhibited by low wind speeds. Wind speeds above five meters per second are sufficient to avoid any risk of flames depending upon the area involved in the oil spill. The polluted waters of the area cannot be used for controlling and extinguishing a fire, as the sea water cooling system will be polluted causing contamination for the machinery installed on board all merchant vessels, crafts, platforms and units in the vicinity.

- Sparks from funnels and blowing down of boilers must be avoided at all costs.
- The affected hulls of the craft will need to be cleaned to prevent further water pollution.

E) Disturbances:

- In the event of an oil spill moving to a port, traffic will need to be diverted causing chaos to the movement of essential commodities and goods such as crude oil, oil products and edible oil, completely disrupting the operation of oil refineries.
- Shortage of essential imported goods will cause hardship to the national economy.
- Fire hazard to the vessels docked in the port increases manifold.
- Containing and removing an oil spill is a slow, time consuming process and prolonged disruption will stall all the activities in the spilled area.
- Ships navigating through polluted waters will have to spend enormous amounts of time and money to have their cooling systems cleaned thoroughly to return them to operational working condition.

5. ENVIRONMENTAL CONCERNS OF OIL AND GAS INDUSTRY: CASE STUDIES

5.1 MUMBAI OIL SPILL, 2010[48]

The Mumbai Oil Spill occurred after the Panamian Ships **MSC Chitra** and **MV Khalijia 3** off the coast of India near Mumbai on Saturday, 7 August 2010 at around 9:50 A.M local time. MSC Chitra, which was bound from South Mumbai's Nava Sheva Port, collided with inbound MV Khalijia-3. The impact of the collision was so severe that MSC Chitra tilted to about 80 degrees soon after the collision, spilling an estimated 400 tonnes of oil in initial few hours. The ship was loaded with an estimated 2,600 tonnes of oil, at the time of the accident. During the accident, there was spillage of about 879 tonnes of oil which travelled long distances to the various coast lines of the Mumbai Metropolitan region (MMR) and nearby areas.

MSC Chitra was also carrying 31 containers of pesticides like pyrethins and the organophosphates. The crude oil moved to different coastline of Mumbai, Thane and Raigad district due to the tidal movement. The shoreline of most of these areas here showed signs of oil from the very next day of the collision. The coastal sediment affected along the shoreline were classified as bedrock, sand, boulders etc. the mangrove stretch was also affected. The degree of impact of the oil spill varied with locations.

[48] "Interim Progress Report on EIA Study on Pollution Due to Oil Spill and Other Hazardous Substances" for MPCB; Submitted by NEERI. Available at <http://mpcb.gov.in/images/pdf/OilSpillinterimreport-NEERI.pdf.>. Last accessed on 22/03/2015.

The Ships: MSC Chitra and MV Khalijia[49]

Steps taken by Coast Guard[50]:

- The coast guard carried out anti-pollution operations by spraying dispersants on the thick oil slick.

[49] Source: Available at < http://in.reuters.com/article/2010/08/10/idINIndia-50748320100810>. Last accessed on 01/04/2015.
[50] "Report on Oil Spill in Arabian Sea" by Maharashtra Pollution Control Board. Available at < http://www.indiaenvironmentportal.org.in/files/oil%20spill%20in%20arbian%20sea_0.pdf.>. Last accessed on 01/04/2015.

- The coast guard provided 5 ships and 2 helicopters equipped with anti-pollution dispersal spray systems.
- The traffic was suspended at the harbor, as fallen containers were floating in the channel.
- Fishing associations were also requested not to carry out fishing activities.

Various agencies involved in the cleanup operations[51]

IOC, TERI, D.G. Shipping Personnel, Officials of Maharashtra Pollution Control Board, District Collectorate Offices, Local Bodies and Police Department etc. involved in clean up operations. Besides that, National Institute of Oceanography and National Environment Engineering research Institute were appointed by the Maharashtra Pollution Control Board to carry out Environment Impact Assessment Study and Risk Assessment and Remedial.

The Effect of Oil Spill:

Marine Life-

Birds: The most shocking images of ecological damage after any oil spill like this one are those of birds smeared with oil. In the Mumbai region, most of the species of birds are migratory. Fortunately, at the time of this incident most of them had not arrived.

Concentrated oil compounds cut off the waterproof cover on birds' feathers and affect insulation. If exposed to cold water and currents, the bird soon develops hypothermia and dies eventually.

[51] Supra; Note 46 at page 37

Caracass of a bird covered in slick.[52]

Mammals: A large number of mammals in the Mumbai Region have adapted to living in or off mangrove creeks. Jackals, Jungle Cats, Rodents and common Mongoose are some of them. Oil can caused serious damage to the water-resistant compounds in the fur of mammals and suffocated the ones which got caught in dense oil-laden creek waters.

Reptiles: Mangroves are home to a rich variety of reptilian fauna, especially snakes. The contact with contaminated water after the oil spill proved to be fatal for most of the reptilian species.

Other marine Flora and Fauna: Oil spills are known to cause severe damage to fish, crabs, clams, mussels, oysters, algae and many insects. Following the oil Spill from MSC Chitra, the authorities around 500 kilograms of fish collected from varies docks and wharfs in Mumbai were found to be contaminated.

[52] Source: Available at < http://www.thehindu.com/news/national/other-states/additional-funds-proposed-for-bnhs/article574614.ece>. Last accessed on 01/04/2015.

Marine Ecosystem-

Mangroves: Over 8.57 lakh mangroves along the coastlines of Mumbai, Thane and Raigad districts were severely affected by the crude due to tidal movements, damaging more than 6.27 lakh of the Avicennia marina species and 2.30 lakh of the Sonneratia alba species, worst hit was in the Navy Nagar. The degradation of the quality of plant life and the water in turn adversely affects the insects and animals that thrive on it. The mangroves had turned black due to thick oil slick. As reported by NEERI, the oil spill during the seeding season of the mangroves mainly affected Elephanta Island, Vashi Creek.

Coastal Activities-

The coastal activities on which is the livelihood of many people in Mumbai region was badly affected due to the oil spill. The slick made it difficult to go into the waters for fishing and other such activities. The damage to shoreline and the adverse effect on the marine life in turn affected the aquaculture and fishing activities. The recreational activities were also affected due to the change in the natural profile of the beaches and the sand dunes following the oil spill.

Analysis

This was a typical case of environment damage due to oil spill from a ship. India has not witnessed any major oil spill until now of the size of BP Oil Spill or the Gulf War Oil Spill but incidents like the Mumbai Oil Spill and the damage that followed expose the loopholes in the implementation of rules and regulations regarding marine pollution due to oil spills. Oil and gas businesses are 'risk and reward' ventures. One cannot rule out that no such incident will take place even after taking all precautions. Keeping this in mind, all the safety measures and precautions should be put to use while taking up any activity in the oil and gas industry. Relief and rehabilitation measures are a part of such plans and safety measures and especially in case of such unprecedented accidents.

5.2 MUMBAI HIGH/BOMBAY HIGH NORTH PLATFORM FIRE, 2005

Location: Mumbai Offshore, India

Fire Event: 27 July, 2005. A vessel collided with the offshore Mumbai High North platform, 160 km west of the Mumbai coast, causing a major fire, completely destroying the platform and resulting in 11 deaths and 11 others missing.

Fire Damage: Complete collapse of the platform

Construction: Steel

Function: Oil and Natural Gas processing

Dimensions: 7 storeys

The Platform:

The Mumbai/Bombay High Field is India's largest offshore oil and gas field. The Mumbai High Basin is 75 km long and 25 km wide, located in the Arabian Sea about 160 km west of the Mumbai coast. The oil and natural gas field is divided into the north and south blocks and has been operated by the Oil and natural Gas Corporation since 1974.

The Mumbai/Bombay High North platform, a 30 years old 7-storey steel structure, was an oil and natural gas processing complex which had a capacity of 80,000 barrels per day of crude production. It was connected to an unmanned NA drilling platform, the BHF platform with residential quarters and the WIN platform also with residential quarters. All these were interconnected by bridges. The MHN facility separated oil and gas carried by risers from the nearby wells, below the NA and BHF platforms, and sent them onshore by separate undersea pipelines.

The Mumbai/Bombay High North platform is in the middle.

The Fire

On 27 July, 2005, a multi-purpose support (MPS) vessel collided into MHN and ruptured a riser carrying oil from the undersea wells to the MHN facility at 04:50 IST, resulting in the break out of a major fire. At that time, the MPS was engaged in a medical evacuation operation in which an injured cook aboard was being transferred to MHN for medical treatment.

However, in a heavy wind and wide tide, the MSV reportedly lost and collided with a riser. The riser broke and crude oil started leaking. The oil caught fire and gas, under high pressure, began to escape. It was reported that a ball of flame fell on the MHN and there was explosion on the platform.

The fire was so intense that the MHN was abandoned in accordance with the disaster management plan of offshore operators. Within two hours, the whole platform collapsed into sea with a few foundation piers left. A Pawan helicopter positioned on it was also lost.

The MHN platform after collapse.

The MPS also caught fire and was towed away by another multi-purpose support vessel but sank on 1 August 2005, about 12 nautical miles from the Mumbai coastline.

A total of 383 personnel were on the MHN complex, the two MPS vessels and an offshore oil rig Noble Charlie Yester at that time. Among them, 11 people died and 11 others were reported missing. The rest were rescued by a combined force of offshore supply vessels, helicopters, and vessels of Indian navy and Coast Guards. Of the 383 pesonnel on board the MHN complex, the Samudra Suraksha and the nearby offshore rig Noblr Charlie Yester, 361 were rescued.

The flow of oil and gas from the affected wells was shut down through the sub-surface safety valves, preventing a large area of pollution.

The Damage

The MHN was completely destroyed in the 2005 fire, along with a helicopter positioned in it. The Multi-purpose vessel causing the fire sank few days later. The property loss faced by ONGC was around 300 Million USD.

Analysis

Incidents like the present one shows the catastrophic consequence of an oil rig fire. The unlimited supply of fuel and oxygen normally contribute to the extremely rapid growth and spread of the fire.

Under normal practice, a multi-purpose support vehicle can only engage an oil rig under normal weather conditions. In addition, the incident vessel was a dynamically positioned vessel with computer-controlled thrusters which could remain in one position on the sea. It still remains unclear as to why the vessel went so close to the MHN, went out of control and hit the riser.

Fire at the time of the incident.

5.3 Krishna-Godavari Basin Blowout (1995)

The KG Basin

The KG basin is a proven petroliferous[53] basin formed on the continental passive margin located on the east coast of India. The basin was formed following the rifting along the eastern continental margin in the early Mesozoic.

The Incident

A raging blowout[54] occurred in an exploratory well in the East Godavari district of Andhra Pradesh in January 1995. The well was spudded[55] in September 1994.

An uncontrolled flow of gas to surface at high pressure led to a blowout. The spewing gas caught fire immediately. The remaining pipes inside the bore were thrown out by enormous pressure of gas. The derrick and the surrounding equipment were gutted after the blowout. The sound of the blowout happening resembled to a rocket engine and the level was so high that no one could hear anything up to 700m distance from the site, necessitated the use of ear plugs. In the night, the intensity of the light caused by the flame was so high that it was visible up to a distance of more than 2 km from the well site. The gas flames were about 200 feet high with temperatures shooting to more than 50^0C. About 1 million m^3/day of gas spewed out with a deafening sound.

Safety Measures

Nearly 6000 families evacuated their houses as panic spread over the neighboring areas about the raging flames of high magnitude. The action plant was promptly taken up by the company personnel to:

- Combat the flames.

[53] Containing petroleum
[54] An uncontrolled release of crude oil and/or natural gas from an oil well or gas well after pressure control systems have failed.
[55] Initial drilling

- Rehabilitate the villagers and setting up of relief camps. The families who left their houses were accommodated in relief camps and were provided food through local administration. Nearly 255 families were staying in the relief camps till the well was capped.
- The local administration, government and public were involved for helping along with the safety rescue personnel.
- Water storage pits were dug up for creating a water umbrella over the flame and cleaning the debris and retrieving the casings etc., from the well and well site.
- Firefighting equipment from the well site was mobilized.

Blowout Control Operation

- Six pumps having total capacity of 20,000 gal/min were used for spraying of water umbrella over the flame to reduce the temperature of the flame and surroundings for the safety rescue personnel to approach and for clearing the debris at the site. To prevent damage of the pumps, they were placed.
- Athey wagons were employed for clearing the debris at the wells site so that it was easier for the safety rescue personnel to reach within 20m radius of the blowout area.
- An irrigation canal was present at about 500m from the site. Water was pumped from irrigation canal to the storage pits. Water was sprayed onto the flame to reduce the intensity of the flames for further rescue and relief operations
- Drums of plastic explosives were dispersed over the flame with the help of Athey wagons, to suck up all the oxygen and to extinguish fire. After many unsuccessful attempts, the fire was finally extinguished which brought a much needed relief to the crew and experts at the well site.
- A new well head and blowout preventer was successfully with the help of water umbrella to cap the well.
- The surroundings were cleaned with the help of cranes, wagons and bulldozer. A relief well was dug up at a distance of 1.5 km from the site of blowout to connect

to the bottom of the blowout well. High density drilling mud was pumped to control the flow of gas from the reservoir to the well bore.

Financial Loss

- The drilling equipment's of the company of worth approx 4 million USD was destroyed. Uncontrolled flow of gas to the surface in the form of blowout at a rate of 1 million m^3/day costing around US$ 34,000 per day.
- About 280 hectares of paddy fields and 470 hectares of coconut trees were affected by the rising flames. A total compensation of US$ 0.2 million for paddy fields and US$ 42 per coconut tree were paid to the owners. Seedlings at the cost of US$ 90 per hectare were compensated.
- US$ 76,000 was paid for the relief work by January 1995 and US$ 96,000 was spent till February 1995 on relief camps. US$ 3,000 per day was paid to the safety rescue team. A coordination team was set up to work round the clock.

Environmental Damage

- This incident resulted in serious environmental damage and also damaged the flora and fauna of the area. The paddy fields, coconut groves and prawn farms within 2 km radius of the site were damaged due to enormous heat of the rising flames. Cultivation of paddy was possible in the next season but palm trees were damaged permanently.
- After 1993 blowout an unknown virus infected the brackish water required for the growth of prawns and resulted in loss of two successive growths.
- The houses in the vicinity of blowout were damaged due to cracks that developed because of high intensity of sound. It also disturbed the sleep of the people. The constant heat and light also affected the life of animals and birds.

Causes of blowout in KG Basin

Such blowouts can also occur unpredictably because of failure of pressure control systems. KG basin contains huge gas a resource, drilling through these reservoirs is of high risk. The main reason for blowout in drilling gas reservoirs too fast can be due to the fact that the gas contained in the formation being drilled becomes mixed with the drilling mud as the bit penetrates the gas bearing strata thus causing to become gas cut and lightened to such extent that it will not overcome the formation pressure.

Analysis

This was an incident of blowouts due to technical failure. Although the use of modern technologies and methods for exploratory activities in the oil and gas industry have minimized the happening of such incidents but if the technology fails, the risk of it still prevails. Given the nature of the works done in this industry it is not immune from mishaps which happen from time to time whether a minor one or a major one. Being one of the most populous countries in the world, the environmental impacts of oil and gas industry can affect a large number of populations. What should be done is that the response to such incidents should be swift using the best available methods to minimize the damage as much as possible.

5.4 Sinking of MV Black Rose[56](2009)

The Incident

The merchant vessel MV Black Rose sank 4km outside the Paradip Port but inside the Port limits. Following the incident of sinking of the ship near the Paradip port, the oil spill from bilges came out and there were reports of traces of dead fish and other marine life along the coast. The coast Guard and the Paradip port trust responded to all minor traces of the oil sheen found outside the ship and it was feared that the ships can't be permanently positioned to respond to minor traces of oil every time as the ship held 930 tonnes of fuel oil. The MoEF had expressed concern that in case the stored oil in the vessel is not evacuated at earliest it could pose serious danger to the environment and marine species in the region.

Response taken

A Florida based company was given the responsibility to do the clean-up and salvage[57] operations. Seven members of the agency visited the spot initially and surveyed the oil stock in the vessel. They observed that 975 tonnes of oil was kept in three sealed chambers of the vessel and were in semi-sold form. The oil had to be pumped out after heating the chambers. The hot-tapping equipment and other related the materials were then brought to Paradip and the salvors commenced their work. They had assured the government the whole operation would be completed in 45 days.

The oil removal work from sunken Mongolian vessel MV Black Rose began in October 2009, after Customs gave clearance to Paradip Port trust (PPT) authorities to transport the pumped out oil through lorries and was completed in November 2009, thereby removing the threat of oil spill from the sunken ship MV Black Rose.

[56]Available at<http://www.indiancoastguard.nic.in/Indiancoastguard/NOSDCP/NOSDCP%20Publications_files/blue%20waters%20Jan%202011.pdf>. Last accessed on 02/04/2015.

[57] The rescue of a wrecked or disabled ship or its cargo from loss at sea.

Analysis

This was another case of oil spill from a ship. The ship sunk inside the port limits. Swift and timely damage control measures by the authorities saved the port from receiving much damage. Timely response from authorities in incidents like these is very crucial. It saved the port from being shut and hampering port activities and business because of oil spill.

The sunken MV Black Rose[58]

[58] Photo Source: Available at http://www.business-standard.com/search?type=news&q=Black+Rose+Ship>. Last accessed on 03/04/2015

5.5 Rupture of Feeder Pipeline in Bombay High (1993)

The Incident

Rupture of feeder pipeline in Bombay High on 17th May, 1993 around 0800 hrs resulted in spillage of crude oil variably estimated between 3000 and 6000 tonnes into the sea. The Contingency plan for combating oil polluting was pressed into action and the vessels belonging to TCG and ONGC fought the spill by skimming as well by spraying chemical dispersants. Several vessels belonging to the Indian coast Guard and ONGC were deployed in service for clean-up operations by skimming as well as spraying dispersants. Under the prevailing environmental conditions and with the use of dispersants, the spill was reported to have broken down into several patches of varying sizes scattered in the region.

The Coast Guard was alerted about the oil spill at 09:30 hr on the same day and by 13:50 hrs, it had commenced spraying of chemical dispersants on the slick. The spread of oil was limited to some extent with the help of the rubberized booms and the oil was partly recovered with the help of the skimmers.

As a follow-up of the decisions taken at various Governmental levels, ORV Sagar Kanya, with an expert group of scientists on board cruised the spill area between 21st and 23rd May, 1993. Another expert scientific group monitored the coastal zone of Murud between 27th May and 1st June, 1993 where the weathered spilled oil was expected to be drifting under the pre-monsoon environmental conditions.

Damage

The oil slick had broken into several patches of varying sizes when the ORV Sagar Kanya arrived on the scene. These oil patches were scattered over a large area and the general trend of drift was in the south easterly direction as predicted on the basis of movement of a hypothetical spill in Bombay High. It was expected that more toxic

volatile components of spilled crude would have evaporated and total mass lost through evaporation along was estimated at 1500-3000 tonnes.

The observed concentrations of floating and dissolved-dispersed petroleum residues in certain regions in Bombay High far exceeded the expected background exposing the water column flora and fauna to much higher environmental stress. Accidently, these regions revealed localized impacts on biota in terms of decrease in the rate of primary productivity and changes in the composition of zooplankton.

The patches of weathered crude reached the coastal waters of Murud on 28th May depriving recreation to the holidaying tourists. Considerable deterioration in water quality was evident when compared with the base-line established on the basis of COMPAS programme of the DOD.

Localised impacts on plankton with mortalities in several instances were also observed. Microscopic examinations revealed phytoplankton cells coated with tarry material and some zooplankton[59] clearly showed the presence of tar in the gut. These effects however were restricted to areas of floating oil and were expected to be only transient. Fairly quick recovery of the aquatic ecosystem was considered likely on the basis of experiences elsewhere. The fish catch however was unaffected.

The scenic Murud beach and the rocky shores around were heavily oiled due to the deposition of tarry lumps on the shore. The deposits melted under the summer heat and percolated into the sand at least upto 5 cm depth. Such heavy deposits are considered to be seriously damaging to the intertidal biota[60]. The oyster beds and the mangroves of the estuarine regions were also affected.

[59] Planktons that consist of animals.
[60] Total collection of a geographic region or a time period, from local geographic scales and instantaneous temporal scales all the way up to whole planet.

Analysis

This incident was a case of environment damage due to pipeline failure/rupture/damage. Oil and gas

Oil Spill being contained with the help of rubber boomers

6. OVERVIEW OF THE OIL AND GAS SECTOR IN INDIA: GOVERNING BODIES, LEGISLATIONS AND REGULATORY FRAMEWORK

The oil and gas industry in India is divided into three segments: Upstream, Midstream and Downstream. Both these segments are governed by different set of laws. The Upstream segment consists of Exploration and Production activities. The Midstream segment consists of Storage and Transportation of crude oil and natural gas. The Downstream segment consists of Refining and Production of petroleum products, and Processing, Storage, Marketing and Transporting of commodities such as crude oil and natural gas.

In India crude oil is produced Onshore and Offshore. Onshore fields are in North-Eastern India (Assam, Nagaland, and Arunachal Pradesh), Gujarat and Tamil Nadu/Andhra Pradesh. Oil India Limited and Oil and Natural Gas Corporation (ONGC) have onshore field for crude oil. Offshore production of crude oil occurs at Bombay High run by ONGC and Private/Joint Venture companies. For natural gas, onshore fields are at Assam, Tripura, Gujarat, Tamil Nadu, Andhra Pradesh and Rajasthan. Offshore production of natural gas occurs at Western area of Bombay High. [61]

6.1 Governing Bodies

The framing of policies for the oil and gas sector in India is done by GoI through the following agencies:

- Planning Commission
- Ministry of Petroleum and Natural Gas
- Ministry of Finance

6.2 Legislations

The power to legislate in respect of matters relating to development of oilfields, mineral oil resources, petroleum and petroleum products and liquids and substances declared by

[61] Available at< http://www.investindia.gov.in/oil-and-gas-sector/>. Last accessed on 20/03/2015

Parliament to be dangerously inflammable is done through following provisions of the Constitution of India:

i) **CoI: Entry 53 of List I**: "Regulation and development of oilfields and mineral oil resources; petroleum and petroleum products"

ii) **CoI: Entry 25 of List II**: "Gas and Gas Works"

- **The Petroleum Act, 1934:** The Petroleum Act was passed in 1934 to address operational issues covering the entire value chain of oil production. The objective of the Act was to *consolidate laws relating to the import, transport, storage, production, refining and blending of petroleum* with powers for regulating these aspects being vested primarily with the Central Government.[62]

- **Oilfields (Regulation and Development) Act, 1948:** This Act was passed in 1948 and under this the Central Government was granted the power to make rules for regulating the authorization of mining leases (for offshore blocks). Mining lease is defined exhaustively to cover all forms of exploring and exploiting mineral oils and all purposes connected thereto[63]. Further, the Act also empowers the central government to determine rates of royalty payable by the holder of the mining lease for onshore as well as the offshore blocks.[64]

- **Petroleum and Natural Gas Rules, 1959[65]:** These Rules provide for the grant of exploration licenses and mining leases. Salient features of the Rules are as follows:

  a) Prohibition on prospecting and mining except under a license or lease granted under the rules.[66]

[62] Available at < http://www.teriin.org/projects/nfa/pdf/working-paper-15-Governance-of-the-petroleum-and-natural-gas-sector-in-india-a-status-note.pdf>. Last accessed on 20/03/2015.
[63] Section 3 (d)
[64] In addition to royalty, the holder of a mining lease for onshore blocks has to pay surface rent to the concerned state government. The rates of surface rents are determined by the central government.
[65] Supra; Note 5
[66] Rule 4

b) Central Government has the power to grant licenses or leases in respect of any land vested with it or mineral underlying the ocean within the territorial waters or the continental.[67]

c) State government has power to grant license or lease over lands vested with it.[68]

d) Person obtaining exploration license obtains the exclusive right to a lease for producing (i.e. extracting) oil/gas over any part of area covered in license.

- **Petroleum and Minerals Pipeline Act, 1962[69]:** This Act has provisions relating to the acquisition and utilization of land for laying pipelines. The central government has been given the authority to acquire the land. Once the land has been acquired, the central government has the option of either keeping the land acquired or transferring it either to the state government or the corporation[70] for which the land has been acquired. The Act also provides for compensation in case of any damage, loss or injury is sustained by any person interested in the land under which the pipeline is proposed to be, or is being, or has been laid. Further, the liability of paying the compensation lies with the concerned authority, i.e., the central or state governments or corporation.

  Section 3- Publication of notification for acquisition, **Section 5**- Hearing of objections

- **Land Acquisition Act, 1894**: The law deals with the acquisition of land for Public purpose. The Act is a general Act which deals with the procedure and the conditions under which a land can be acquired.

[67] Rule 5(i)
[68] Rule 5(ii)
[69] Supra; Note 5 at page 6.
[70] Corporation means anybody corporate established under any Central, Provincial or State Act, and includes:
a) a company formed and registered under the Companies Act, 1956 (1 of 1956); and
b) a company formed and registered under any law relating to companies formerly in force in any part of India.

The only requirement is that the land can only be acquired for public purpose as per Section 3(f) of the Act.

- **Oil Industry (Development) Act, 1974[71]:** Under this Act, the Oil Industry Development Board was created at a time when the need to promote self-reliance in the oil and gas sector was realized. The mandate of the Board is to facilitate the development of the sector The Board is responsible for collecting the oil industry cess on the blocks that have been awarded to upstream oil companies on a nomination basis. It also extends financial assistance to companies in the sector in the form of loans.

- **Petroleum and Natural Gas Regulatory Board Act, 2006[72]:** This Act provides for the setting up of the Regulatory Board to regulate the refining, processing, storage, transportation, distribution and sale of petroleum, petroleum products and natural gas excluding the production of crude oil and natural gas. The PNG Act provides for a legal framework for downstream gas sector regulation and development of natural gas pipelines and city or local gas distribution networks.

- **NELP[73]-** NELP was formulated by the Union Government with DGH as the nodal agency in 1997-98 to provide a level playing field to both public and private sector companies in E&P of hydrocarbons. DGH has been entrusted with the responsibility of implementation of NELP. NELP promotes investments in E&P sector by facilitating allotment of exploration blocks through international competitive bidding. Since 1999, NELP has accelerated the pace of petroleum and natural gas exploration activities by providing level playing field for all parties to compete for award for exploration acreage. National, private and foreign

[71] Supra; Note 12
[72] Supra; Note 12 at page 7
[73] Available at < http://petroleum.nic.in/docs/nelp.pdf>. Last accessed on 20/03/2015.

companies compete on equal terms and conditions for the blocks[74] offered through bidding process.

- **Environmental Laws[75]:** Under the **PSC**, the Union Government and the contractor knowing that the complex environment of petroleum operations cause some impact on the environment, have to conduct petroleum operations with due regard o concerns with respect to protection of the environment and conservation of natural resources and in particular:

  a) employ modern oilfield and petroleum industry practices and standards including advances techniques, practices and methods of operation for the prevention of environmental damage in conducting its petroleum operations;

  b) take necessary adequate steps to:

  i) prevent environmental damage and where some adverse impact on the environment is unavoidable, to minimize such damage and the consequential effects thereof on property and people;

  ii) ensure adequate compensation for injury to persons or damage to property caused by the effect of petroleum operations.

Before commencing E&P, it is mandatory to conduct an **Environmental Impact Assessment (EIA)** for the project site, in accordance with the Environmental Impact Assessment Notification, 1994.[76]

Other than these the different environmental laws and laws related to shipping in the country namely **Forest Conservation Act 1980, Indian Fisheries Act 1897, Marine**

[74] An oil exploration block is a large area of land, typically in 1000s of sq. kilometers, that is awarded to oil drilling and exploration companies by a country's government.
[75] Available at <http://www.dghindia.org/pdf/MODEL%20PRODUCTION%20SHARING%20CONTRACT(MPSC).pdf>. Last accessed on 15/03/2015.
[76] Environmental Impact Assessment is notified in exercise of the power conferred under Section 3(c) of the Environmental Protection Act, 1986.

Fishing Regulation Act 1978, Biodiversity Act 2002, Merchant Shipping Act 1958 have relevant provisions related to marine pollution and other kinds of pollution.

- **International Conventions[77]:**

  a) **MARPOL[78]:** MARPOL refers to Marine Pollution. MARPOL 73/78 is the International Convention for the Prevention of Pollution From ships, 1973 as modified by the Protocol of 1978. It entered into force on 2 October 1983 and it has 169 parties. It is one of the most important environment conventions on marine pollution and prevents the pollution from Oil Spills, Noxious Liquid Substances carried in Bulk, Harmful Substances carried in Packaged Form, Sewage and Garbage. It centers on minimizing the pollution of the seas, including dumping, oil and exhaust pollution. India is a party to MARPOL 73/78.

  b) **UNCOLS[79]:** The United Convention on the Law of the Sea (UNCLOS) 1984 is a set of rules for the use of the world's oceans which covers 70% of the Earth's surface. The convention was concluded in 1982 to replace a group of treaties adopted in 1958 that were considered to be out of date. UNCLOS came into force in 1994 and to date 159 countries have joined the treaty including the EU and **India.** US has stayed out of it. The 1982 convention contains 320 articles and 9 annexes. This convention has been a primary instrument in the international legal framework for the preservation and protection of marine pollution.

  As regards to the vessel source pollution, Part XII of UNCLOS provides the main core provisions and provides a jurisdictional legal framework for the protection of marine environment in terms of flag, coastal and port States jurisdictions. In general, coastal states have complete jurisdiction over marine

[77] Available at <http://www.dgshipping.gov.in/Content/PageUrl.aspx?page_name=ShipManualChap10.> Last accessed on 02/03/2015.
[78] Ibid
[79] Available at < http://www.un.org/depts/los/convention_agreements/texts/unclos/closindx.htm>. Last accessed on 02/03/2015.

resources up to 200 nautical miles from its shore. This jurisdiction, or property interest, includes all marine resources up to 200 nautical mile zone. Beyond this zone is the High Seas. **No sovereign country under UNCLOS can claim independent jurisdiction to this region.** This area exists under the notion of *mare liberum*, or Freedom of the High Seas.

Article 194 clause 3(b) of the convention specifically requires that States take measures to minimize pollution from vessels. Article 195 of UNCLOS prescribes obligations on States to prevent trans-boundary pollution. Vessel source pollution has this distinct feature that it effect is not limited to just one state but it causes trans-boundary pollution as seas are connected between the States and shipping is the main mode of carriage of cargo.

c) **Basel Conventions[80]:** The Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal was adopted on 22 March 1989 by the Conference of Plenipotentiaries in Basel, Switzerland, in response to a public outcry following the discovery, in the 1980s, in Africa and other parts of the developing world of deposits of toxic wastes imported from abroad. **India ratified the Convention in the year 1992**.

The objective of the Basel convention is to protect human and the environment against the adverse effects of hazardous wastes. Its scope of application covers a wide range of wastes defined as 'hazardous wastes' based on their origin and/or composition and their characteristics, as well as two types of wastes defined as 'other wastes'- household waste and incinerator ash. The principal three aims of the Convention are:

i) The reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes, wherever the place of disposal;

[80] Available at < http://www.basel.int/TheConvention/Overview/tabid/1271/Default.aspx>. Last accessed on 01/04/2015

ii) The restriction of trans-boundary movements of hazardous wastes except where it is perceived to be in accordance with the principles of environmentally sound management; and

iii) A regulatory system applying to cases where trans-boundary movements are permissible.

In addition to these, the MoPNG is actively considering policies on exploration and production of unconventional hydrocarbons, especially **shale gas and coal bed methane** (CBM). The draft policy on shale gas has been formulated and shale gas blocks may begin to be awarded in the next few years. However, there are significant environmental concerns regarding shale gas explorations which would need to be addressed.

Shale gas is natural gas produced from shale. Shale is a fine-grained, clastic sedimentary rock composed of mud that is a mix of flakes of clay minerals and tiny fagments of other minerals, especially quartz and calcite. Shale gas is defined as fine grained reservoir in which gas is self-sourced, and some of the gas is stored in the sorbed[81] state. Shale gas is not just 'shale'. Productive gas shales vary from organic-rich to fine-grained rocks. Shale has low matrix permeability, so gas production in commercial quantities requires fractures to provide permeability. Shale gas has been produced for years from shales with natural fractures; the shale gas boom in recent years has been due to modern technology in hydraulic fracturing to create extensive artificial fractures around well bores[82].

India has vast shale deposits across the Gangetic plain, Assam, Gujarat, Rajasthan, and many coastal areas. Gas has long been found in shale across the world, but its extraction has been viewed as uneconomic because of shale's low permeability — gas does not flow easily through this rock. So, exploration for oil and gas has traditionally focused on limestone and sandstone, which have high permeability.[83]

[81] Sorption is a physical and chemical process by which one substance becomes attached to another.
[82] Available at http://www.ey.com/Publication/vwLUAssets/Shale_Gas_-_Key_considerations_for_India/$FILE/EYIN1210-084-Shale-gas.pdf. Last accessed on 01/04/2015.
[83] Ibid

India contains a number of basins with organic-rich shales, mainly the Cambay, Krishna Godavari, Cauvery, and Damodar Valley basins. There are some other possible reserves such as the Upper Assam, Vindhyan, Parinhita- Godavari, and South Rewa, but it was found that either the shales were thermally too immature for gas or the data with which to conduct a resource assessment were not available.[84]

Shale basins in India are geologically highly complex. Many of the basins, such as the Cambay and the Cauvery, have horst and graben structures and are extensively faulted. The prospective area for shale gas in these basins is restricted to a series of isolated basin depressions. While the shales in these basins are thick, considerable uncertainty exists as to whether the shale is sufficiently mature for gas generation.[85]

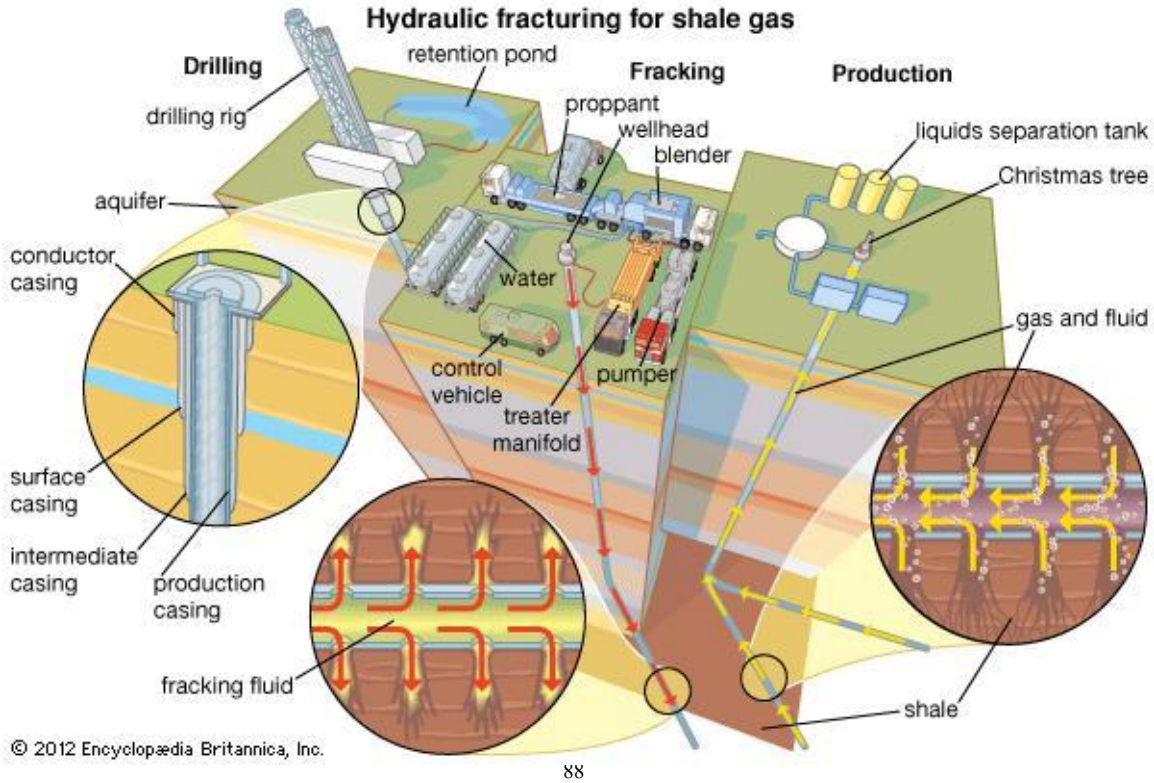
Conventional gas can occur by itself or in association with oil. Coal bed methane (CBM), which is extracted from coal beds, is also an unconventional gas and, in terms of depth, occurs much closer to the land surface than other similar gases. However, shale rock is sometimes found 3,000 meters below the surface. Therefore, after deep vertical drilling, there are techniques to drill horizontally for considerable distances in various directions to extract the gas rich shale. A mixture of water, chemicals, and sand is then injected into the well at very high pressures to create a number of fissures in the rock for the discharge of the gas. The process of using water for breaking up the rock is known as 'hydralic fracturing' or 'fracking'. The chemicals help in water and gas flow and tiny particles of sand enter the fissures to keep them open and allow the gas to flow to the surface. This injection has to be done several times over the life of the well.[86]

Proposed Shale Gas Exploration Policy in India[87]

There is an obvious interest in exploring for shale gas domestically, given the enormous success in the US. The MoPNG has identified six basins as potentially shale gas bearing.

[84] Supra; Note 60 at page 55.
[85] Ibid
[86] Ibid
[87] Available at < http://www.teriin.org/policybrief/docs/Shale_gas.pdf>. Last accessed on 01/03/2015.

These are Cambay, Assam-Arakan, Gondwana, Krishna-Godavari, Kaveri, and the Indo-Gangetic plain.



[88]

Shale gas production has met with stiff resistance from environmentalists and people. Some **key issues** are as follows[89]:

- *Defining geological conditions*: Care should be taken to define clearly what an unconventional condition is. The definition should consider all the parameters that define a hydrocarbon due to shale gas condition. There may be situations when both shale and conventional hydrocarbon resources lie in the same vertical zone.

[88] Source: Available at < http://www.britannica.com/EBchecked/topic/1655635/fracking>. Last accessed on 01/04/2015.

[89] "Shale Gas: Key considerations for India" , Petrotech 2012, 10th International Oil and Gas Conference and Exhibition, under the aegis of Ministry of Petroleum and Natural Gas, Government of India.

In such situations, the definition should serve as a guide to clear any dispute that might arise. Globally accepted parameters should be considered for defining the unconventional condition.[90]

- *Classification of all unconventional gas resources*: Unconventional gas resources come in various forms such as tight gas, coal bed methane, and shale gas. All these unconventional resources require similar infrastructure for development. A single classification may help lowering cost of production by providing economy of scale for the operations.[91]
- *Criterion for selection of the developer*: Shale gas geology is in its infancy in India and one cannot be sure if the shale gas economics are beneficial until a few wells are drilled. The financial criteria may consider a strong balance sheet and sufficient cash reserves. Technical criterion could consider a technological alliance with an overseas entity or availability of technical experts or understanding of technical knowhow.[92]
- *Acreages size and terms of lease*: A block below the threshold area may lead to slapdash approach in resource exploitation and prevent it from becoming a pure capital market play. The right size of the shale gas blocks will invite interest from established entities. The terms of the lease should give adequate period for the complete exploration of the awarded blocks. Though shale gas extraction seems more controllable than producing gas from a conventional hydrocarbon reservoir, but the term of the lease should be adequate for completion of commercial exploitation without much slack.[93]
- *De-regulation framework*: Gas price freedom/deregulation in the US has been mentioned as one of the turning point for Shale gas success. Complete freedom to price and sell shale gas within India will be of key interest to established players.[94]

[90] Ibid
[91] Supra; Note 67 at page 57.
[92] Ibid
[93] Ibid
[94] Ibid

- *Fiscal Regime*: A progressive fiscal regime with tax credit for inputs and time linked royalty regime will entice the established players. Ideally, income tax exemptions may be avoided given the long tenor.[95]
- *Promote the development of service capabilities*[96]: The inadequate oilfield service sector capacity and suitable equipment are potential bottlenecks preventing the faster development of shale gas in the country. This is one of the challenges that India will need to address to develop its unconventional resource potential. The service level intensity for shale gas development is typically higher than that of conventional oil and gas activities. In the US, the domestic service industry played a pivotal role in supporting the country's shale industry. In comparison, there is a shortage of critical oilfield equipment in India. Moreover, equipment imported from other countries will have to be modified to suit local conditions due to differences in terrain. The geological characteristics of shale gas plays vary across regions. Therefore, the exact replication of technologies and techniques employed in the US may be not possible in India. As such, there is a need to foster an environment, which is conducive for investment in development of high specification equipment required to conduct shale gas operations. With many oilfield service companies looking to export the techniques they have used successfully in North America to international markets, the Government of India can encourage their participation in India.
- *Address environmental concerns*: Before initiating shale gas development in the country, it is necessary to learn the lessons from studies underway on the environmental and public health impact of shale gas development in the US and use them to shape appropriate regulation. With the increase in shale gas

[95] Supra; Note 67 at page 57

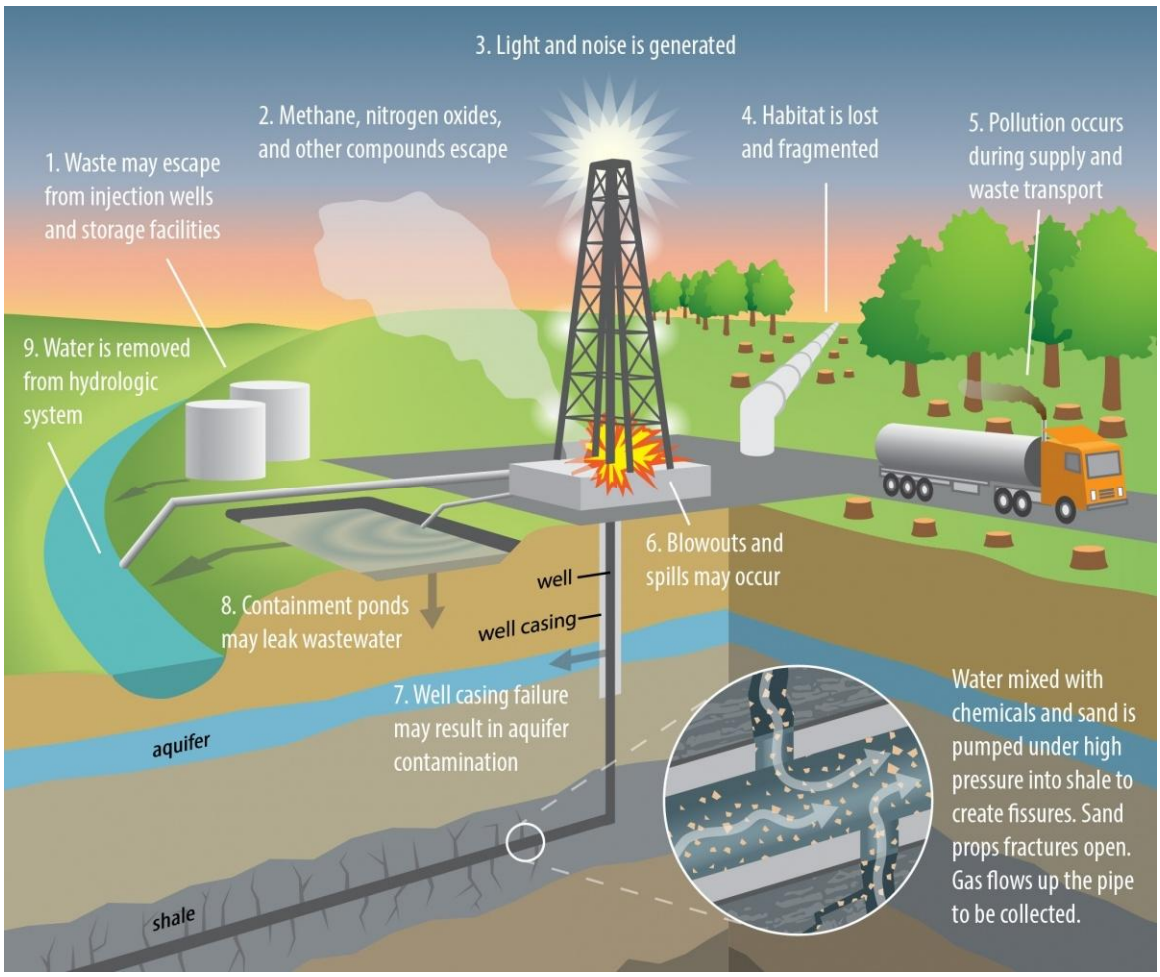
[96] "DOE's Early Investment in Shale Gas Technology Producing Results Today," NETL press release, Available at <http://www.netl.doe.gov/publications/press/2011/11008-DOE_Shale_Gas_Research_Producing_R.
Html> 2 February 2011; "China 5-Year Shale Gas Planning Unveiled Today," SinoCast Energy Beat, 16 March 2012.
via Factiva, © 2012 SinoCast LLC; "The US and China: Towards a Clean Energy Economy," The White House, http://www.whitehouse.gov/blog/2009/11/17/us-and-china-towards-a-clean-energyeconomy, 17 November 2009. Last accessed on 01/04/2015.

production brought about by the application of hydraulic fracturing "commonly termed as 'fracking' techniques, there has been a corresponding increase in concerns about the potential impact of the process on public health, drinking water and the environment. The issue has become increasingly contentious in the US, which has had several years of shale gas production experience, largely pertaining to the parameters against which the impact needs to be assessed. In response to raised public concerns, various studies are underway on the environmental and public health impact of shale gas development in the US. Many states in the US are deliberating to impose a moratorium on drilling activities until the results of the study are released and robust measures are implemented. Currently, most countries in Europe appear to be adopting a "wait and see" approach on the issue. Even South Africa, with significant shale gas reserves, has suspended drilling activities in the region. The extensive use of water, especially in water-deficient countries such as India, may put severe pressure on water supplies. The efficient disposal of waste-water from drilling operations is likely to be another debatable issue. Moreover, the exploitation of shale reserves in ecologically sensitive areas may lead to public opposition.[97]

- *Address social concerns*: The availability of land is not a major challenge in the US, given its vast open spaces; however it may be a vital issue in highly populous countries like India. The physical footprint related to shale gas activities is considerably larger than that of the exploitation of conventional oil and gas. The typical well pad needs to be large enough to contain the drilling rig equipment, wastewater ponds, storage and pipeline infrastructure and facilities for staff and contractors.[98]
- *Overcome talent shortfall*[99]: The Indian oil and gas industry is facing a dearth of talent, which could delay projects and impact production. According to Ernst & Young's estimates, approximately 50% of the current oil and gas workforce has

[97] Supra; Note 74 at page 59
[98] Ibid
[99] . "Final Report on Unconventional Gas in Europe," Philippe & Partners. Available at <http://ec.europa.eu/energy/studies/doc/2012_unconventional_gas_in_europe.pdf>. Last accessed on 02/04/2015.

more than 20 years of experience and the majority of them may retire within the next five to ten years. The attrition levels are high, as 7% of the current workforce may leave the industry in the next five years. To address these issues, there is a need for significant efforts to attract new talent[100].



Shale gas production and its impact on environment.[101]

[100] "HR challenges in the Indian oil and gas sector," Ernst & Young.

[101] Source: Available at <http://wws.princeton.edu/news-and-events/news/item/fracking-dark-biological-fallout-shale-gas-production-still-largely>. Last accessed on 01/04/2015.

7. CONCLUSION

India's energy industry is going through a tough and challenging phase. It has always been dependent on coal for its primary commercial energy requirements. After coal, the oil and gas industry put together dominates this sector. The growing economy of the country and various changes incorporated different sectors has put pressure on this sector for fulfilling the energy needs of the country. The petroleum products serve as a feedstock for several consumer goods.

The oil industry holds a major potential of hazards for the environment and impacts it on different levels: air, water, soil and consequently all living beings on the planet. All the activities going on in this industry can cause widespread pollution. Wastewaters, gas emissions, solid wastes etc. are the common sources of pollution in the oil and gas industry. Other impacts include intensification of the green house effect, acid rain, poorer water quality, groundwater contamination. It also contributes to biodiversity loss.

Despite its potential threats to the environment, oil industry plays a positive role in society as well, creating many jobs and generating a significant volume of tax revenues and royalties to the national government. The conventional sources of energy have been fulfilling the energy needs for a long time. Recently, there has been some new discoveries in the energy industry in the form of unconventional sources of energy like shale gas etc. But all these activities in the oil and gas industry have some potential to harm the environment.

In the recent times, there has been a growing concern from environmentalists, nodal agencies, governments and common people towards environmental damage from the oil and gas industry. The increasing commitment to promote sustainable development has become a demand from the society. Voices are being raised to change the methods and technologies used in the oil and gas industry and make it more environment friendly. Not only the people but the companies have also started realizing the benefits that they are going to make using pollution control mechanisms and modern eco-friendly technologies

for their activities. The biggest of all these benefits being positive image in the eyes of the consumers and the creation of goodwill.

In the light of the facts and circumstances and the case studies analysed, following suggestions will be suggested:

- For companies:
  - ✓ To employ the best practices and modern oilfield methods for taking up any activity in the oil and gas industry
  - ✓ To employ properly trained personnel who have the knowledge about the modern methods used by the oil and gas industry
  - ✓ To provide support and technology to such persons
  - ✓ To provide for waste management techniques for proper and timely disposal of waste generated
  - ✓ To do proper site inspection and assessing environment damage that will be caused during the whole operations and trying to keep it to minimum
  - ✓ To design monitoring programmes for keeping a check on these operations from beginning to end
  - ✓ To share technology with other companies and governments and make it available to everyone so that all can benefit from any such technology
  - ✓ To provide for a proper rehabilitation programme for the masses rehabilitated and for any loss of livelihood caused
- For governments;
  - ✓ Before offering any area for exploratory activity, any data collected should be made available on a common platform

- ✓ To do a proper background check about a company before entering into any contract with them
- ✓ To implement rule and regulations regarding environment pollution strictly and penalties for their violations should also be implemented strictly. This process should be made time bound.
- ✓ When there arises a need for companies to switch technologies, proper time should be provided for it and keep a check that the companies stick to it
- ✓ To try to get hands-on new and modern technologies for the benefit of the industry and for that matter enter into contracts for sharing technology with other nations and foreign companies.

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