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ENVIRONMENTAL MANAGEMENT IN OIL AND GAS UPSTREAM INDUSTRY IN INDIA

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ABSTRACT

Oil and gas upstream industry in India falls under category 'A' as per the Environmental Impact Assessment notification, 2006, and require prior environmental clearance before any drilling activities. The industry has potential to negatively impact surrounding environment and socio-economic conditions if not handled properly. The impacts of industrial activities have been felt on air, water, soil and even biodiversity. Although significant statutory provisions are there to deal with negative impacts during different stages of activities, these are noticed in various components of environment. The present paper throws light on the environmental issues and their management associated with the industry and give details about the rules, regulations and acts present in India.

INTRODUCTION

Awareness of the importance of environmental issues has become more and more central to the thinking of the oil industry (E&P Forum/UNEP, 1997). Oil and gas exploration and production has the potential to cause severe environmental degradation, not only to the physical environment, but also to the health, culture, and economic and social structure of local and indigenous communities (Wawryk, 2002). The oil and gas industry comprises two parts: upstream- the exploration and production (E&P) sector of the industry; and downstream-the sector which deals with refining and processing of crude oil and gas products, their distribution and marketing. The steps involved in E&P for oil and gas involves a) Seismic survey, b) Exploratory drilling, c) Appraisal, d) Development and production, and e) Decommissioning and restoration. India has substantial quantity of oil reserves in its territory. Crude oil production in 2011-12 up to December 2011 was about 28.699 Million metric tonnes (MMT) (Fig. 1) (MoPNG, 2012). The total sedimentary area basins including onshore and offshore areas within Indian territorial limits works out to be 3.14 million km^2 of which about 15% of area is still unexplored (Fig. 2). Some of the important oil and gas basins in India are Assam-Arakan fold belt, Cambay basin, Upper Assam, Krishna-Godavari, Cauvery, Rajasthan, Kutch, Himalayan foreland and Mahanadi. Measures are being taken to enhance hydrocarbon

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reserves and increase production such as thrust on new and difficult areas, implementation of improved oil recovery (IOR) and enhanced oil recovery (EOR), and better reservoir delineation (MoPNG, 2012). It is therefore imperative that oil and gas E&P activities in these basins in near future will demand proper management of environmental and social concerns.

Environmental impacts of oil exploration and production

Potential environmental impacts arising out of E & P are; a) Human, socio-economic and cultural impacts, (changes in landuse pattern, changes in local population level, changes in socio-economic system, changes in socio-cultural system, aesthetics and transportation system), b) Atmospheric impacts (from flaring, venting, and purging gases, combustion processes such as diesel engines, fugitive gases from various sources, airborne particulates from soil disturbance) (principal gaseous pollutants include carbon dioxide, carbon monoxide, methane, volatile organic carbons and nitrogen oxides, and sulphur dioxides and hydrogen sulfide (depending upon the sulphur content of the hydrocarbon and diesel fuel). Flaring of produced gas is the most significant source of air emissions, particularly where there is no infrastructure or market available for the gas), c) Aquatic impacts (from produced water, drilling fluids, cuttings and well treatment chemicals, process, wash and drainage water, sewerage, sanitary and domestic wastes and, spills and leakages), d) terrestrial impacts (from physical disturbance as a result of construction, from contamination resulting from spillage and leakage or solid waste disposal and, access roads), d) Ecosystem impacts (through change in water, air and soil/sediment quality and through disturbance by noise, extraneous light and changes in vegetation cover. These may directly affect the ecology), and e) Potential emergencies (spills, blow out, explosion, fires, natural disasters, war and sabotage) (E & P Forum/UNEP, 1997).

Significant waste streams specific to onshore oil and gas development activities include: drilling fluids and drilled cuttings, produced sand, completion and well work-over fluids, and naturally occurring radioactive materials (NORM). Because drilling waste may contain chemical additives (Table 1) or hydrocarbons, it has the potential to impact vegetation, flora and fauna, and water bodies if released in an uncontrolled manner into the environment. It can also increase loading of contaminants in the receiving environment when the method of disposal is discharge to the environment. The disposal methodology for drill mud and cuttings is an important element of how they are handled in the context of individual operations (GRI, 2012). Whereas produced sand originating from the reservoir and separated from the formation fluids during hydrocarbon processing can be contaminated with hydrocarbons; depending on the field reservoir characteristics, NORM may precipitate as scale or sludges in process piping and production vessels. Oil and gas development activities can also generate noise during all phases of development including during seismic surveys, construction activities, drilling and production, transportation. Project footprints resulting from exploration and construction activities may include seismic tracks, well pads, temporary facilities, such as workforce base camps, material storage yards, workshops, access roads, airstrips and helipads, equipment staging areas, and construction materials extraction sites (including borrow pits and quarries). Impacts may include loss of, or damage to, terrestrial habitat, creation of barriers to wildlife movement, soil erosion, and disturbance to water bodies including possible sedimentation, the establishment of non-native invasive plant species and visual disturbance (E & P Forum/UNEP, 1997; IFC, 2007). Top soil is an important component of the environment which remains at higher risk but is given less priority for prevention from contamination during E & P.

Environmental management

All environmental issues related with oil and gas upstream industry can be taken care of with appropriate precaution, budget and willingness to mitigate the impacts. All the three forms; liquid, gaseous and solid, of pollutants are generated (Table 2) from various sources in the industry. Air quality impacts can be estimated by the use of baseline air quality assessments and atmospheric dispersion models to establish potential ground level ambient air concentrations during facility design and operations planning. Air emission specifications may be considered during all equipment selection and procurement. Flaring and venting of natural gas is a waste of a valuable energy resource, contributing to emissions of greenhouse gases (GHGs) and air pollutants, and may have adverse impacts on community health and wellbeing. Measures consistent with the Global Gas Flaring and Venting Reduction Voluntary Standard (part of the World Bank Group's Global Gas Flaring

Table 1. Drilling mud additives

S. No.	Raw material	Function
1.	Barite	Weighting Agent.
2.	Carboxy Methyl Cellulose	Filtration (fluid loss) reducer and supplementary viscosifier.
3.	Defoamer	Non-hydrocarbon base defoamer for water based muds.
4.	Chrome free Lignosulphonate	For thinning and dispersing water based mud.
5.	Shale Inhibitor	High molecular weight PHPA shale encapsulator & inhibitor.
6.	Oxygen Scavenger	Liquid oxygen scavenger.
7.	Temperature Stabilizer	Deflocculant & rheology stabilizer up to 260°C.
8.	Soda Ash	Calcium reducer.
9.	Sodium Bicarbonate	Calcium reducer.
10.	Bentonite	Viscosity & fluid loss control.
11.	Caustic Soda	pH controller, increases alkalinity.
12.	Concentrated Corrosion inhibitor	Amine-Based Corrosion Inhibitor.
13.	Viscosifier	Polyanionic Cellulose for Fluid Loss control & supplementary viscosity.
14.	Fluid Loss Additive	Pregelatinized corn starch for Fluid Loss control.
15.	Poly Glycol	Polyoxyalkalene Cloud Point Glycol for bore-hole stability by clay inhibition and lubricity.
16.	Potassium Chloride	For potassium ions and bore-hole stability by clay inhibition.
17.	Dispersant	Polyanionic lignite resin for water-based mud dispersion.
18.	Sodium Chloride	For sodium ions and bore-hole stability by clay inhibition.
19.	Detergent	Biodegradable drilling detergent.
20.	Bactericide	Aldehyde bacteriacide for water based drilling fluids.
21.	Flocculent	Flocculent for Bentonite based water based muds.
22.	Viscosifier	Xanthum Gum for primary viscosity in water based drilling Fluids

Reduction Public-Private Partnership (GGFR) (WB, 2006)) should be adopted when considering flaring and venting options for onshore activities (GRI, 2012). Produced water contains a complex mixture of inorganic (dissolved salts, trace metals, suspended particles) and organic (dispersed and dissolved hydrocarbons, organic acids) compounds. Its management and disposal should be evaluated and integrated into production design. The alternatives may include injection into the reservoir to enhance oil recovery, and injection into a dedicated disposal well drilled to a suitable receiving subsurface geological formation; other possible uses includes irrigation, dust control, or use by other industry considering chemical nature. Gray and black water from showers, toilets and kitchen facilities should be treated. Separate drainage systems for drainage from process areas that could be contaminated with oil (closed drains) and drainage water from non-process areas (open drains) should be available with sluice gates to the extent practical (Fig. 3). Non-hazardous and hazardous wastes routinely generated at onshore facilities including general office and packaging wastes, waste oils, paraffins, waxes, oil contaminated rags, hydraulic fluids, used batteries, empty paint cans, waste chemicals and used chemical containers, used filters, fluorescent tubes, scrap metals, and medical waste, among others can be segregated into non-hazardous and hazardous wastes for consideration for re-use, recycling, or disposal (Fig. 4). Waste management planning should establish a clear strategy for wastes that will be generated including options for waste elimination, reduction or recycling or treatment and disposal, before any wastes are generated (IFC 2007). Alternatives for the treatment and disposal of drilling fluids and drilled cuttings may include one, or a combination of, the following: Injection of the fluid and cuttings mixture into a dedicated disposal well, into the annular space of a well, storage in dedicated storage tanks or lined pits prior to treatment, recycling, and/or final treatment and disposal; On-site or off-site biological or physical treatment to render the fluid and cuttings non-hazardous prior to final disposal using established methods such as thermal desorption in an internal thermal desorption unit to remove NADF for reuse, bioremediation, land farming, or solidification with cement and/or concrete. As per MoEF Notification (GSR 546 (E) dated 30th December 2005), for disposal of Drill cutting (DC) and drill fluids from on shore installation following should be followed; DC originating from onshore or locations close to shore

Table 2. Pollutants and their sources (adapted from ILFS, 2010)

Liquid effluents		Gaseous emissions		Solid wastes	
Sources	Pollutants	Sources	Pollutants	Sources	Pollutants
•Formation (produced) water •Hydrostatic testing waters •Other waste water (Sewage water, drainage water, tank bottom water, fire water, equipment and vehicle wash water, oily water, and non process industrial wastewater)	•Inorganic compounds (dissolved salts, trace metals, suspended particles) •Organic compounds (Dispersed and dissolved hydrocarbons, organic acids) •Chemical additives (corrosion inhibitors, oxygen scavengers, and dyes)	•Combustion from power and heat generation •Use of compressors, pumps, and reciprocating engines •Flaring and venting of hydrocarbons •Fugitive emissions	•Nitrogen oxides •Sulfur oxides •Carbon monoxide and particulates •Additional (H_2S, VOC, Benzene, Ethyl benzene, Toluene and Xylene, Glycol, PAH) •GHG	•Drilling fluids and drilled cuttings •Produced sand •Completion and well workover fluids •Naturally occurring radioactive materials (NORM)	•Complex colloidal mixture of water, bentonitic clays, chemical additives, Trace amount of oil. •Unused hydrochloric acid, Paraffin, waste cement, metal casing, dissolved formation materials •Heavy metal impurities (Mercury and cadmium) •Weighed brines, acids, methanol and glycol

line and separated from water based mud (WBM) should be properly washed and unusable drilling fluids (DF) such as WBM and oil based mud (OBM), synthetic base mud (SBM) should be disposed off in a well designed pit lined with impervious liner located off site or on site (Fig 5). The disposal pit should be provided with additional leachate collection system. Final disposal routes for the nonhazardous cuttings solid material should be established, and may include use in road construction material, construction fill, or disposal through landfill including landfill cover and capping material where appropriate (IFC, 2007). Volumes of drilling fluids and drilled cuttings could be minimized using high efficiency solids control equipment or using slimhole multilateral wells and coiled tubing drilling techniques. Careful selection of fluid additives (Table 1) and fluid system is affective in pollution prevention and control measures for spent drilling fluids and drilled cuttings (IFC, 2007).

Noise impacts may be estimated by the use of baseline noise assessments for developments close to local human populations. For significant noise sources, noise dispersion models may be conducted to establish the noise level guidelines. Decommissioning and restoration of onshore facilities usually includes the complete removal of permanent facilities and well abandonment, including associated equipment, material, and waste disposal or recycling. Timely completion of final reclamation is as important as the initial planning. Revegetation alone does not constitute successful reclamation. Restoration of the original landform is a key element in ensuring that the effects of oil and gas development are not permanent. To achieve final reclamation, the well site may be recontoured to original contour or to a contour that blends with the surrounding landform, stockpiled topsoil redistributed, and the site revegetated (API, 2009). About 150mm loose top soil may be removed before site preparation using mechanical means like dozer and saved at a nearby place for later use during site restoration. Top soil should be stored in proper condition with proper bunds, slope and efforts for retaining its fertility (Fig. 6).

Regulatory and legal framework in India

Any E & P project in India is governed by various acts, rules, and regulations set by MoEF at the national level and other regulatory agencies at the state and local level (CPCB, 2010). Various environmental standards, specification and guidelines are also applicable. Projects in India are also governed by Oilfields

Table 3. Regulatory requirements associated with oil and gas exploration in India

S.N.	Legislation	Domain
1.	Air (Prevention & Control of Pollution) Act, 1981 with Rules	• Protection of Air quality. • Consent to establish (CE) from state pollution control boards (SPCBs) for establishment and Consent to operate (CO) for activities causing air pollution from DG sets. • Compliance to National Ambient Air Quality Standard.
2.	Water (Prevention & Control of Pollution) Act, 1974 with Rules	• Protection of water quality, discharge of sewage. • Obtaining CE & CO for activities causing water pollution from SPCBs.
3.	Environment Protection Act (EPA), 1986 with Rules	• Overall environmental protection. • Compliance to general environmental (Air, water and noise) standards issued under Environment (Protection) Rules. • Disposal of solid waste, drill cutting and drilling fluid for drilling operation notified vide notification G.S.R. 546 (E) dated 30th August, 2005. • Compliance to minimum national standard (MINAS) of Oil Drilling and Gas Extraction industry as notified vide notification dated G.S.R 176 (E) dated April 1996.
4.	EIA notification, 2006 under EPA 1986	• To get environmental clearance from MoEF, exempting seismic activity.
5.	Forest Conservation Act, 1980	• Prevention of diversion of any forestland for non-forest purposes.
6.	Hazardous waste (Management, Handling & Transboundary Movement) Rules, 2008	• Obtaining authorization from SPCB for generation, handling and storing of hazardous waste like drill cuttings and drilling fluid, waste oil, sludge. • Following guidance for handling, storing and disposal of such hazardous wastes.
7.	Public Liability Insurance Act, 1991 and Rules 1991	• Providing immediate relief to the persons affected by accident occurring while handling any hazardous substance and for matters connected therewith or incidental thereto.
8.	Noise Pollution (Regulation and Control) Rules, 2000	• Ensure compliance with Ambient Noise Standards in accordance to land use of the area.
9.	The Wildlife (Protection) Act, 1972	• Protection to the species of flora and fauna and wildlife habitat to establish a network of ecologically important protected areas.
10.	Motor Vehicle Act and Rules, 1989	• Requirement of Pollution Under Control Certificate (PUCC). • Proper labeling of the vehicles carrying hazardous substances.
11.	Oil Mines Regulations (OMR) 1984 under the Mines Act 1952	• Overall drill site safety. • Storage of material and protection against pollution of environment at the drill site.
12.	Petroleum and Natural Gas Rules, 1959 under oilfields (Regulation and Development) Act, 1948	• Obtaining exploration license for oil and gas from the state government to identify the prospects of a particular area and to follow the instructions mentioned.
13.	Manufacture, Storage and Import of Hazardous Chemicals Rules, 2000	• Notifying regulatory authority of storage of hazardous substances like Petroleum products. • Follow guidance on such storage, maintain updated material safety data sheet (MSDS), submit annual safety report to authority and to prepare onsite emergency plan.
14.	Production Sharing Contract	• Impact assessment study for exploratory drilling operation to prepare Environmental Impact Assessment (EIA) report along with Environment Management Plan (EMP) and approval of the same from the MoEF.
15.	Petroleum Act with Rules 2000	• Obtain License for storage of petroleum substances. • Comply with guidance and safety measures for storage and transportation of petroleum substances for the project.
16.	The Explosive Acts, 1984 with	• Obtain license for storage of explosives.

Contd.....

	Rules, 1983	• Comply with guidance and safety measures for storage and transportation of explosive substances for the project.
17.	The Ancient Monuments and Archaeological Sites and Remains Act, 1958 and Rules, 1959	• Protection of archaeological sites, ancient monuments and demands fencing or covering and/or otherwise preserving such monuments and sites.

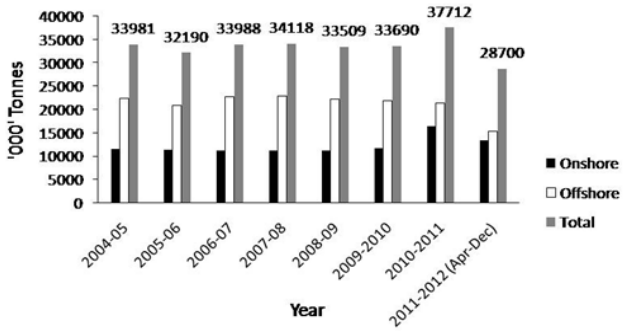

Fig. 1 Crude oil production in India (adapted from MoPNG 2012)

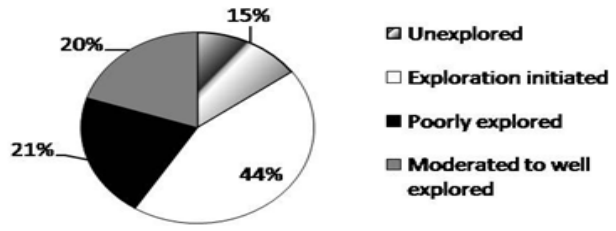

Fig. 2 Level of oil exploration in India out of total sedimentary area basins (adapted from IL&FS 2010)

(Regulation and Development) Act, 1948 and Petroleum & Natural Gas Rules, 1959, which make provision for the regulation of petroleum operation and grant of licenses and leases for exploration, development and production of petroleum in India. Central government has framed Environment (Protection) Act, 1986 to broadly encompass and regulate an array of environmental issues. Detailed regulatory requirements associated with oil and gas drilling are given in Table 3.

As per the Environment Impact Assessment (EIA) notification 2006, all projects of oil and gas exploration, development and production comes under category 'A' in the schedule and shall require prior environmental clearance from the Central Government in the Ministry of Environment and Forests. Before commencement of drilling operation certain clearances/licenses should be obtained from Central and State Governments as Environmental Clearance (EC), Forest Clearance (FC), Consent to establish (CE), Consent to operate (CO) and Authorization for Hazardous wastes (HW). EC takes approximately 210 days which is given by MoEF as per EIA notification, 2006. After screening, scoping, public consultation, and appraisal of the application form along with EIA report and findings of Public Hearing, the MoEF may issue the clearance through recommendations given by Expert Appraisal Committee (EAC). FC takes approximately 270 days which is given by State Forest Department. Application is submitted to Divisional Forest Officer (DFO), followed by joint site verification with Range Forest Officer (RFO). DFO scrutinize and process the application form and submit the report to Conservator of Forest (CF). CF submits the report remarks to Chief Conservator of Forests (CCF) who also acts as the Nodal Officer. Nodal Officer submits report to Principal Chief Conservator of Forest (PCCF) who in turn recommends it to Regional Chief Conservator of Forests (RCCF). RCCF formally approves the FC and inform to PCCF who in turn issue letter regarding the amount of NPV. The project proponent deposit the amount to PCCF and area is demarcated by DFO. Ultimately the area is demarcated and trees are removed by DFO. As per the Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981, it is mandatory to obtain CE (before commencement of the construction activities) and CO (prior to commencement of the Drilling activities on the site) from respective State Pollution Control Board (SPCB). The process for obtaining CE involves making an application in a prescribed format to respective SPCB along with required documents and scrutiny fees. This is followed by verification by Regional Officer (RO) (SPCB) and presentation by project proponent. For CO, the application form is accompanied with required documents and assessment of the environmental management system proposed in CE by SPCB. This is followed by presentation by project proponent. CE is for one time and required only at the time of establishment of new unit or before carrying out expansion/ modernization in the existing unit whereas CO is granted for a specific period and needs to be got renewed every time after expiry. Industries which are covered under the provisions of Hazardous Waste (Management, Handing and Transboundary move-

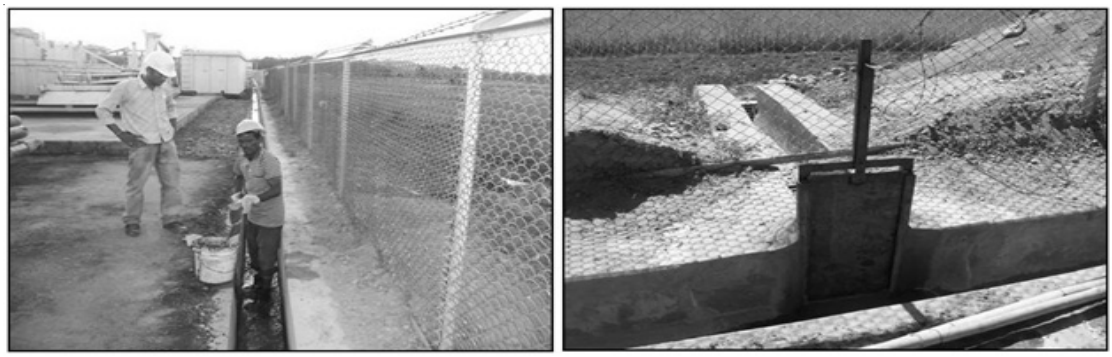

Fig. 3 Proper drains around the site with facility of sluice gate to regulate the flow; in Assam, northeast India.

Fig. 4 Waste collection and segregation unit within a drill site in Assam north east India

ment) Rules, 2008 (in this case Oil and gas industry) are also required to obtain Authorization under the provisions of the rules. The filled in Application Form along with the complete details of the procedure for collection, handling, transportation and disposal of the waste is submitted to the Member Secretary, SPCB. As per The Water (Prevention and Control of Pollution) Cess Act, 1977, Petroleum Industry is required to pay the water Cess quarterly to SPCB under the four purposes for which the water is consumed in the industry: 1) Industrial cooling, spraying in mine pits or boiler feeds, 2) Domestic purpose, 3) Processing which results in water pollution by biodegradable water pollutants, and 4) Processing which results in water pollution by pollutants which are not easily biodegradable. As per the stipulated conditions in EC, the industry needs to submit a six monthly compliance report to MoEF, CPCB, & SPCB and a monthly monitored air/water/noise quality data along with statistical interpretation to SPCB. As per the stipulated conditions in CO, the industry needs to submit yearly Environmental Statement to MoEF, CPCB, and SPCB and monthly compliance report to SPCB. As per the stipulated conditions in Authorization, the industry needs to submit Annual return to SPCB. As per the Water Cess Act 1977, the industry needs to submit monthly return to SPCB.

CONCLUSION

Various environmental issues are always associated with exploitation of oil reserves. In recent times the social impact of operations, especially in remote communities, has also been recorded. Broadly these issues are manifested at both local and global levels including habitat protection and biodiversity, air emissions, marine and freshwater discharges, incidents and oil spills, and soil and groundwater contamination. In India oil drilling is spread over entire length and breadth from Gujarat to Arunachal Pradesh and from J&K to Tamil Nadu. Although a gamut of statutory provisions are there to safeguard the environment and social concerns but their proper implementation is still lacking. It is therefore important to understand the link between exploration and development of oil fields and requirement of environmental management.

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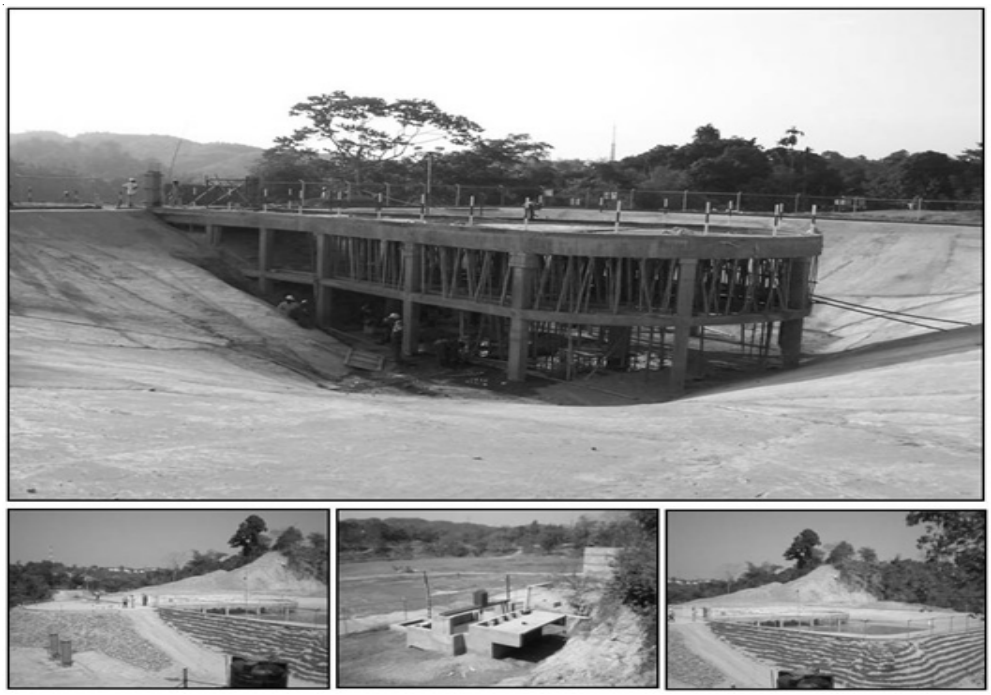

Fig. 5 A well designed drilling waste pit with leachate collection and treatment system in Assam north east India

Fig. 6 Properly stored and maintained top soil with mulch treatment around a drilling site in Assam, Northeast India

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