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THE OFFSHORE OIL EXPLORATION AND ITS EFFECTS UPON THE MARINE ECOSYSTEM.

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Abstract: The activities for the economic generation remain corner stone of the modern society to get developed, sustained, and self-sufficient with the available resources. In presence of multiple economic activities, the exploration of natural deposits of oil and gas is one of the highly profitable business sectors. This intensified competition among the various oil and gas explorers has eroded the very foundations of the environmental regulations / laws. The degree of damage is variable and diversified in nature. The proportion of marine ecosystem pollution in comparison to terrestrial environment remains highly risky than our consideration. The inter-relationship between the various components parts of environment are directly linked together and similarly affects each other and has combined impacts on the global climate. The offshore oil and gas exploration carry out throughout the world, to boost the domestic economies. Almost all factors of environmental pollution are due to anthropogenic activities on the land, continental shelf and sea shores around the world. The offshore drilling for oil and gas generated numerous factors responsible for environmental damages on land, and marine environment in general. The use of wide range of chemicals, and unexpected restraints causes severe release of chemicals, oil, and produced water to contaminate the surrounding environment, with severe impact upon the fish, the habitat, local biodiversity and ecosystem in general. Technological advancement has minimized many risks, such as, Bioremediation, phytoremediation, biodegradation, biosensors, bioreactors, and biomarkers, if it may be applied from the gross root levels, would be proved secure, sustained, and modern application in the field of offshore oil or gas exploration.

Key words: Establishment, Exploration, Environment, Ecosystem, Biodiversity. Restoration.

1.1 Introduction. Since last 20Thcentury offshore drilling acquired much success and intense competition for trapped oil and gas among the technologically, advanced nations, around the world. Initially, shallow water drilling experienced, and it was due to lack of technology to perform deep water drilling on the seabed. In recent years the deep drilling has been much successful and highly productive, in comparison to shallow water drilling. The practice proved quantitatively as well as qualitatively highly result oriented in several ways. The method proved in much way sound, secure, safe, and serene being at the deep sea. The degree of possible risks is minimized; though, it's not riskless and error free. However, technology has minimized the risks and margin of errors. The oil business doer tycoons have been turned to wealthy millionaires to billionaire; therefore, these company owners can go even beyond the borders even to harsh environmental regions, from green fields to terrain areas, from the deserts to deep seabed in today's world.

1.2 Oil Availability and Biotic Factor Interaction.

Crude oil, refined petroleum products, and polycyclic aromatic hydrocarbons remain omnipresent in various environmental compartments. Petroleum and its products can accumulate in food chains where they disturb biochemical or physiological activities of many organisms, can be cause of carcinogenesis of some organs, and genetic mutation in the genetic material, damage in reproductive capacity and /

or causing hemorrhage in exposed biotic factor of environment. The cause / effect of oil pollutant are usually calculated by using biological end point parameters referred to as biomarkers. A biomarker is an organism, which is used in soliciting the possible detrimental effect of a pollutant on the environment or the living biota. Bio monitoring is a capable means of calculating the negative effect of an environmental pollutant. In a broader sense, the biological markers (biomarkers) are measurement in any biological samplings that will clarify the relationship between exposure and effect such that adverse effects might be prevented **(NRC. 1992).** It should be introduced whenever a waste discharge or oil spill has a probable significant destruction on the ecosystem. It is preferred to chemical monitoring because the latter does not take into account factors of biological implication such as the combined effects of the contaminants on DNA, protein or membrane. Some of the advantages of bio monitoring include the provision of natural integrating functions in dynamic media such as water and air, possible bioaccumulation of pollutant from 103 to 106 over the ambient value and / or providing early warning signal to the human population over an impending danger due to a toxic substance. Microorganisms can be used as an indicator organism for toxicity assay or in risk assessment. Tests performed with bacteria are considered to be most reproducible, sensitive, simple, economical and rapid **(Mathews, 1980).**

1.3 Normal composition of crude oil.

Crude oil and petroleum are complex mixtures of several polycyclic aromatic compounds and other hydrocarbons **(Domask, 1984).** The major hydrocarbon classes found in diesel fuel **(Mackay et al., 1985)** are the normal alkanes (rapidly degraded), branched alkanes and cycloalkanes (difficult to identify), the iso -prenoids (very resistant to biodegradation), the aromatics, (fairly identified and much more soluble than other hydrocarbons), and finally the polar ones containing mainly sulphur, oxygen and / or nitrogen compounds. Non-hydrocarbon compounds may also be found in crude oil and they include porphyrins and their derivatives **(Callot and O. campo, 2000)**. Metals that could be found in crude oil via their association with porphyrins include nickel, vanadium, iron, zinc, cobalt, titanium and copper **(Chicarelli, et al., 1990.)** Some priority contaminant of petroleum hydrocarbons and crude oil include benzene, heptanes, hexane, isobutene, isopentane, PAHs such as benzo[a] anthracene, benzo[b] pyrene etc. **Onwurah, and etal (2007).**

Distillation components of Nigerian Brass crude oil.

Distillation fraction	Composition (%)	Chain length
Gasoline	11.2	C_4 -C_{10}
Naphtha	18.1	C_4-C_{10}
Kerosene	16.9	C_{10} – C_{20}
Gas oil	15.7	C_{15}-C_{40}
Heavy gas	25.8	C_{40} and above

Table No: 1, Adapted from Adams and Jackson, 1996.

Solubility (in water) of some common components easily analyzed in crude oil.

Components	Examples	Solubility (mg/L) 28 ± 2 °C
Alkanes	n-butane	101.00
	n-decane	0.05
Branched alkanes	2-methylpentane	78
Cycloalkanes	Cyclohexane	55
Olefins	1-pentene	148
Monoaromatics	Benzene	1,760
	Toluene	470
	Ethyl benzene	140
Polyaromatics	Naphthalene	30
Phenols	Phenol	82,000
	2,6. dimethyl phenol	4,600
	2,4,6- trimethyl phenol	14,000

Table No: 2, Adapted from Adams and Jackson, 1996.

Six Tier Company formulas for Oil & Gas Exploration.

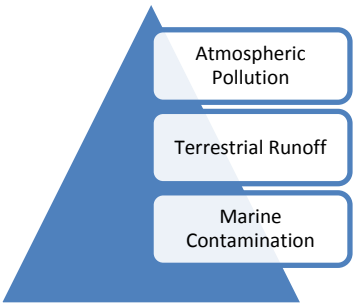
Desk Study: Identifies areas with favorable Geological conditions.	Establish Environmental Management System. Environmental Profile.
Aerial Survey: If favorable features revealed then.	Environmental Profile.

Seismic Survey: Provides detailed information on Geology.	Preliminary Environmental Assessment / review. Environmental Training. Operational Procedures.
Exploratory Drilling: Verify the presence or absence of Hydrocarbons, and quantifies the reservoir.	Preliminary Environmental assessment / review. Environmental Tanning and Environmental Assessment. And Operational procedures.
Appraisal: To determine if the reservoir is economically feasible to develop.	Preliminary Environmental assessment / review. Environmental Tanning and Environmental Assessment. Operational procedures.
Development and Production: Produces oil and gas from the reservoir through formation pressure, artificial lift, and possible advance recovery techniques until the reservoir deplete.	Environmental Impact Assessment. Environmental Training. Environmental Monitoring, Auditing. Waste management and operational procedure.
Decommissioning & Rehabilitation: May occur for each are above forms.	Site Assessment. Implement of site restoration plan. Environmental Monitoring. Operational Procedures.

Table No: 3, EPA Handout about offshore drilling.

1.4 Interrelationship between Environmental Pollution and Global Warming. A Pyramid.

The concept of relationship among the various components of global environment is highly connected; naturally, it has certain effects which are directly recognizable throughout the world. The chemical release in the form of smoke becomes part of the climatic system, ultimately, these chemicals and green gases touch the land, their ultimate destination in the form of land runoff through various channels like rivers, estuaries, and the rainfall channelized to the sea, and causes the marine pollution. The degree of land runoff may be variable country to country, as it depends upon the degree of industrialization and chemical release into environment. Furthermore, to collect the accurate data regarding the land runoff is extremely difficult process, the contaminants and their release into environment much more complex to provide exact figure. There is a wide range of pollutants, released into sea at the natural boundaries of the land the sea. While considering the pollutants such as; nitrates, phosphates, metals, oil, and certain other hydrocarbons. The distribution of these contaminants causes heavy disturbance in the natural biogeochemical cycles in the marine environment. Further situation deteriorates when any volcanic eruption takes place, which may be a natural process, no human activities involved in it. If the degree of contaminants is greater than this situation turns into huge catastrophe and creates un-sustainability into natural environment of marine ecosystem such as oil and gas seepage on the seabed, flooding on the land, increased splits on the fault lines, formation of algal blooms, mud flow from the earth crust, and emission of certain dangerous gases into atmospheric environment and these gases become part of air mass. (The data show that land-based and atmospheric sources account for about two-thirds of the total input of contaminants into the marine environment, constituting 44% and 33%, respectively. The main pollution press undoubtedly falls on the shelf zones and especially on the coastal areas.) **[Windom, 1992].**



Triangular Relationship of Pollution.

Fig No: 3. Shallow & Deep Oil & Gas Rigs platforms at Gulf of Mexico. EPA 2009.

Fig No: 1. Oil platform P-51 off the Brazilian coast is a semi-submersible platform. EPA handout 2009.

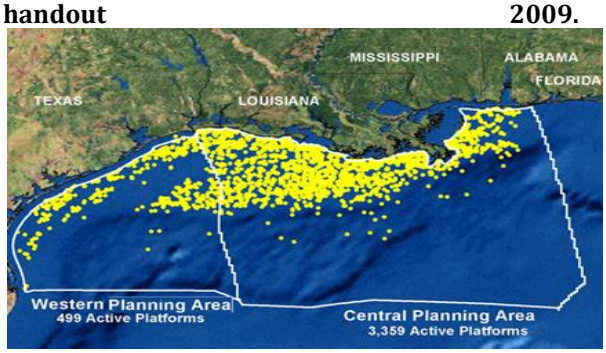


Fig No: 2. The 3,858 oil and gas platforms extant in the Gulf of Mexico in 2006. EPA. 2006.

5. Research Methodology.

Research mainly focuses upon the literature review, online surveys, published relevant data, and certain international standards for exploration and ecosystem management.

6. Study Area.

The anthropogenic activities on land and coasts, offshore oil and gas exploration activities. Its possible effects upon the human, environment, biodiversity and marine ecosystems.

7.1 Discussion.

The marine oil pollution is caused by multiple reasons, such as natural seepage from the bottom of the seabed, and anthropogenic activities on the land and continental shelf of the sea, transportation, discharge from the oil tankers, marine non- tanker shipping, illegal discharges, offshore drilling discharges, on land sewage water, oil terminals, river land runoff, incomplete combustion and releases. Except incomplete combustion, remaining all spills has direct impact on **Hydrosphere.** While drilling discharge and incomplete combustion has direct impact on the **Atmosphere**. Almost all sources of seepage has severe and direct impact on **Local** marine environment except a few sources has **Regional** impacts. However, the distribution of **Biosynthesis** by marine organisms' impact is **Global** in nature.**[NRC, 1985; GESAMP, 1990; 1993].**

7.2 Floating Mechanism of Oil Spillage Oil in Marine Environment.

The process of physical transformation of oil initiates at the very first moment of contacting with the sea water. However, the speed, duration, and progress of physical transformation depend upon the properties, composition, and behavior, and physical conditions of marine environment. The main characteristics of oil transformations are their dynamism, especially at the first stages, and the close interaction of physical, chemical, and biological mechanisms of dispersion and degradation of oil components up to their complete disappearance as original substances. Similar to an intoxicated living organism, a marine ecosystem destroys, metabolizes, and deposits the excessive amounts of hydrocarbons, transforming them into more common and safer substances. **(Patin Stanislav. 1999).**

7.3 Physical Transportation of Oil in the Sea.

Three fundamental forces play a vital role in the transportation of oil in the sea.

I. **Gravitational Pull.**
II. **Viscosity of Oil.**
III. **Surface Tension of Water.**

Only ten minutes after a spill of 1 ton of oil, the oil can disperse over a radius of 50 m, forming a slick 10-mm thick. The slick gets thinner (less than 1

mm) as oil continues to spread, covering an area of up to 12 km2 [**Ramade, 1978].** After several days oil transform to gaseous state, and loses many contents, remaining components turns to some volatile elements, slowly the slicked oil further becomes thinner and thinner, ultimately, degenerates into smaller pieces of thin film over the water. Again changes are bound to further degeneration of oil, as it's due to extreme meteorological and hydrological pressure, especially the power and direction of wind, finally breaks into smaller fragments with thickness about 0.1 mm and float much away from the original place of spill.

7.4 The Oil Spillage and Consequences.

Several incidents collectively cause oil spillage at the exploring rigs. Generally, most frequent causes of oil spillage taking place, due to human error, extreme environmental conditions, such as, storms, nonstop rainy conditions, leakage of pipes, and failure of equipment's in response to timely fashion. When, these conditions prevail for much time, consequently, accidents occur with a variable degree of intensity, prove to be disastrous to man, installations, and environment in general. Therefore the risk of damage and catastrophe remain constantly over the rig and extended structure. Sometimes, accidents turn into worst case scenario, if the blowout of oil or gas is uncontrollable during the drilling or production levels, oil or gas remains inside the wellbore, drill pipe, or up in the annulus. If this situation persists, the oil / gas escalates, due to extreme pressure reaches at the surface of the rig platform causes huge damage, resultant, installation turns into a fireball, colossal destruction of life, equipment, and environment turns into a nightmare.

8.1 Impacts of Oil Spillage.

8.2 Physical, Financial, and Engineering Losses due to Oil Spillage.

Oil spills severe injuries and sometimes death of staff due to accident. There many instances the rig structure completely turned into a fire ball, created most unwanted situation on the platform.
In case of a failure of single part of an instrument, may multiply with series of failures and destruction on the rig platform, causing serious financial losses to a company.

If the fire escalates during the production, it may intensify the situation, due to fire, consequently, there is no alternative but to halt the production, none know the resumption of production in days.

8.3 Environmental Impacts of Oil Spillage.

The direct impacts upon the marine environment, is due to certain drilling activities. The major aqueous impacts resulting from exploration activities are.

- Produced Water.
- Drilling fluid, mud, cutting and treating chemicals.
- Sewerage, sanitary, and domestic waste.
- Leakage and spill.
- Cooling water.

During the process of drilling, the principal source of effluent is produced water, which plays fundamental source for contamination. Further, volume of waste depends upon the stage of exploration, during the seismic surveys, the quantity of waste is minimized albeit, and it increases on the stage of production. The chief constituent parts bentonite and clay, being chemically inert and non-toxic in nature. However, certain other chemicals are Biodegradable and remain slightly toxic after dilution. The effects of heavy metals linked with the drilling fluids, and cuttings have been limited effects due to their bioavailability. While oil based cutting has increased effects, due to toxicity and redox potential.

8.4 Environmental Impact on the Marine Biodiversity.

The effects of oil and gas drilling on the on the marine environment in general, while, the biodiversity of the region get affected particularly. These impacts are serious, severe and long lasting in nature. However, its intensity depends upon the quantity of oil leakage, temperature, water waves, and the direction and speed of wind. The continental shelf of the Gulf of Mexico is also distinctive for intense seepage of natural liquid and gaseous hydrocarbons. Some authors **[Kennecott et al., 1992]** believe that this can lead to formation of **oil slicks** and **tar balls** on the sea surface, which makes assessing and identifying anthropogenic oil pollution more difficult. In any

case, the input of oil hydrocarbons from natural sources into the Gulf of Mexico is larger than in many other areas.

In the Baltic Sea, the Sea of Asov, and the Black Sea, the leading role in oil input most likely belongs to land-based sources, which are dominated by river inflow. The Danube River alone annually brings to the Black Sea about 50,000 tons of oil, half of the total oil input of about 100,000 tons **[Konovalov, 1995].**

The most concentrated tanker traffic exists in the Atlantic Ocean and its seas, which accounts for 38% of international maritime oil transportation. In the Indian and Pacific Oceans, this portion is, respectively, 34% and 28% **[Monina, 1991].**

Substances and impacts on Marine Organism.

S/No:	Substances	Impacts
1.	Substances Causing Mechanical Impacts. (Suspensions, films, solid wastes).	Damage the respiratory organs, digestive system, and receptive ability.
2.	Substances with saprogenic properties (sewage with a high content of easily decomposing organic matter) those cause oxygen deficiency.	Mass mortality of water organisms, and appearance of specific Microphlora
3.	Substances causing toxic effects (e.g., heavy metals, chlorinated hydrocarbons, dioxins, and furans).	Damage the physiological processes and functions of reproduction, feeding, and respiration.
4.	Substances with mutagenic properties (e.g., benzo(a)pyrene and other polycyclic aromatic compounds, biphenyls, radionuclides)	Cause carcinogenic, mutagenic, and teratogenicity effects.
5.	Oil and oil products are a group of pollutants that have complex and diverse composition and various impacts on living organisms.	Physical and physicochemical damage to carcinogenic effects.

Table No: 4 (PatinStanislav. 1999).

8.5 General Effects of Oil Spill on Marine Ecosystem.

- Discharged oil pollutes water.
- Increased Water Turbidity.
- Ecosystem Destruction.
- Change in Biodiversity.
- Forced Fish Migration.
- Fish Respiratory Problems.
- Fish Habitat Loss.
- Loss of spawning, molting, and nesting of fish.

Generally oil spill devastates the marine biodiversity in multiple ways, although, its effects may categorized into long terms and short-terms basis.

8.6 Oil and Water Interaction.

The floating or spilled oil has two fundamental impacts, such as; by spreading itself (Oil) over the water in a thick or may be thin layer; oil hampers directly the light penetration into water on one hand, while it reduced the water capacity of absorbing the oxygen into it. Thus oil reduces the rate of photosynthesis, mainly in algae, Phytoplankton, it reduces the rate of respiration in deep ocean fishes and other living organisms. Furthermore, oil reduces the insulating capacity of birds, and turn birds feather compacted and sticky to fly for longer distances, ultimately birds become victim of predators. Suspended oil easily penetrates into fish gills, and other bodily opening cause serious and severe effects respiratory system, hatched and un-hatched eggs in the water.

8.7 Impact of Suspended Oil on Seabed &Sedimentation.

Suspended oil on the water become weighty by bonding with the minerals, forms grey colored smaller piece like chocolates, and ultimately deposit on the seabed / ocean floor. The direct effect of deposited oil can be easily observed on it. It affects in two way process, firstly it forms a silting / deposition of extra layer the seabed / ocean bed, secondly, it affects the local plant community to grow over the silted oil mud on the sea floor. Consequently, the natural process of purification of water through biodegradation reduced and the ecosystem remains under the environmental stress for a long time.

Sources and estimates of crude oil or its products released into the marine environment (Baker, 1983)

Sources	Quantities (K. tones)
Transportation accidents	390
Tanker operations (washings)	710
Atmospheric/fuel combustion	300
Municipal, industrial and surface run-offs	1,400
Natural seeps / erosion	300

Table No: 5 Source of Oil Marine Spill, adapted from Onwurah, 2007.

8.8 Oil Impacts on Coastal Vegetation, Animals, and Fishes.

In case of major spill on the coastal areas have direct, immediate effects upon the animals, fishes, and vegetation reported around the globe. Oil's poisonous effects are so severe, that organisms may dies in days, hours, and even in minutes of oil spillage, such as worms, microorganisms, and others may be affected drastically. Human and certain other living organisms living near the coastal areas also been affected in due course of time. The cyclic (aromatic) hydrocarbons have low boiling points are even more detrimental to human and other living organisms health issues, such as benzene, toluene, and xylene. Furthermore, certain chemicals such as; **Phenantherene**, and **Naphthalene** are highly poisonous for the fishes in the marine environment. Fortunately, these compounds are much more water soluble than saturated hydrocarbons therefore these compounds affects fishes without any direct contact. Luckily, these compounds are highly volatile in nature, therefore, their harmful effects decreases with the passage of time. If the oil spills in the mangroves areas, it affects directly it. **Pneumatophores**, thus plant becomes unable to respire, it's due to oil cover around the plant. Oil affects roots and suffocates the plant. Reduced rate of light and oxygen affects process of photosynthesis Predominantly, mangroves work as a hatchery for prawns and other fishes as a breeding ground to hatch out the eggs. Oil affects severely the process of reproduction and spawning. It delays the cell division **(Mitotic division)** in the eggs, reduction of respiration among the new born, and produces the mating reactions among the fishes, and decreased temperature affects the **zygote** eggs. Furthermore, oil blocks solar rays to keep shallow water temperate, which ideal for the growth of mangroves and creatures. **(Perry, 1980). (Krebs and Tamer, 1981).**

8.9 Commercial devaluation of Prawns and other Sea Fish food.

The world production of fish is in billion tons, and generates billions of dollars through the world. The fishing industry plays a vital role in job creation to poor population of the world. An estimated weight of fish catchment was about 100 million tons approximately in 2000, while the generated revenue was about 75 billion dollars a years in fish industry around the world.

Fish catchment around The world.

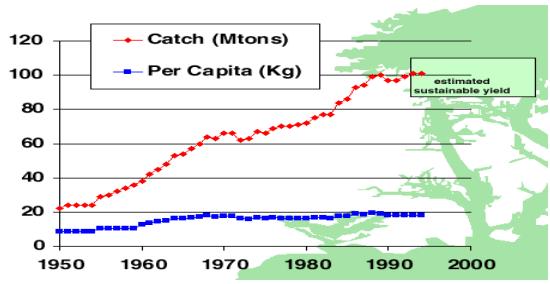


Table No: 6. Food and Agricultural Organization. (2009).

Thus in case of oil spill in the coastal areas it affects severely the production, quality, health, and size of the fish. Oil spill affects the fish reserve, ultimately stocks in the region, oil smell in their bodies affects severely, the poisonous fishes causes many diseases in consumers, destruction of hatcheries, diseased fish due to oil

settling in theirs gills, cause suffocation in the fish, damaged immune system, and reduced commercial value of fish in the market.

8.10 Nature cleanses and restores the marine ecosystem itself.

Suspended oil in rocky shores, deep seabed takes too much time by ecosystem to get normalized. There are various conditions in which spilled oil remained for large time. According to estimation sometimes an ecosystem takes 70 years to restore completely. In this cleaning process high tides play important role especially in the rocky shores of a sea. Due to superior wind velocity creates highest vibration to move the water current with maximum speed. Thus the nature itself continues to clean the environment with help of air and water currents. The Microbial activities play the fundamental role in **decomposition** inside the deep seabed and in rocky shores. However; the microbial decomposition remains less active in the cold sea. Thus, natures cleanse the marine environment minimum time span from 2 months to 15 years.**(Dunnet, 1982), (Calfee, et al., 1999).**

Conclusion.

The seismic surveys, oil rigs installations, transportations, leakage of pipes, failure of machines, blowout of facility, and decommissioning of offshore installations are ubiquitous and responsible for oil spill in the marine environment. The effects of spill are variable from local to regional, and some effects are global in nature. Hydrocarbons being volatile in nature have ability to spread rapidly far and wide in the atmospheric component of environment. The scale and the degree of devastation are also variable in nature, further depends on the quantity and quality of oil being shipped, transported or leaked. The effects upon the ecosystem have far and wide on the organisms and flora and fauna. These impacts ranging from change of habitat, to breeding declining, death, or being wounded. Furthermore, the reduced rate of reproduction, as well as effects upon the normal genotypes to phenotypes in nature. The gene mutation, abnormal pairing of genes, even the quantity, and size or organisms.

Natural cleansing of ecosystem an ability provided by nature itself to consume the contaminants, and contaminants ability to degenerate itself in the process of time span, albeit, there must be systematic discontinuity of releasing contamination. As the oceans and seas have ability to absorb contamination, however, it requires large span of time to 2 months, to 15 years, even in some cases up to 70 years. Whereas, the anthropogenic activities, on land and the ocean are unhampered, therefore, the time for natural cleansing is not possible.

Bioremediation, biodegradation phytoremediation, and bioreactors are much powerful tools to recognize the issues of oil spill and play pivotal role in removing the pollutants in an affected area of environment. Furthermore, modern application of environmental biotechnology has wider role to control the contaminants on higher scale. To mutate the genes according to our own requirements to meet the demands of environment is possible and in many ways perfect to provide solutions as desired.

Application of biosensors could be highly supportive to assess the early warning systems to recognize the impending dangers to be faced by the mankind on the globe. Biomarkers having capability to predict the undesirable effects oil spill and the impacts on the biota of the region. The biomarkers are the living organisms being affected themselves and help in predicting at the threshold level. Technological advancement has paved the way to reduce, recycle, and reuse of various materials and being in use by various organization to assess the situation on precautionary basis.

Environmental economics is another issue which relates the cleansing issues of the contaminants, what we paid in 70s has risen the cost of it fourfold today, it's better to cleanse, should practice most sophisticated technologies to avoid, damage, destruction, and leakage of oil on primary levels.

There must be review of environmental laws, directions, regulations, regular inspections, and applications of modern technologies, with rewards, and punishments. The ISO standards protocol policies should be applied strictly to reduce the risks of environmental degradation and enhancing the idea of environmental sustainability around the globe.

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