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ORIGINAL RESEARCH ARTICLE

STRATEGIC APPROACH FOR CONTROLLING SOIL AND GROUNDWATER CONTAMINATION IN URBAN AND RURAL AREAS OF NIGERIA

O. J. Oyebode

(Department of Civil and Environmental Engineering, College of Engineering, Afe Babalola University, Ado-Ekiti, Ekiti State, Nigeria)

** Corresponding author's email address: oyebodedare@yahoo.com*

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ABSTRACT

Soil pollution and groundwater contamination are rampant in urban and rural areas of various developing countries including Nigeria. The quality of groundwater is a vivacious concern for human beings since it is directly associated with the human welfare and it is needed to conserve water resources. This paper x-rays strategic approach for controlling soil and groundwater contamination to enhance the efficiency of civil and environmental engineering design through recent trends and practice which will play a vital role in handling environmental pollution. Strategic approach highlighted involves the formulation and implementation of the major goals and initiatives based on consideration of resources and an assessment of the internal and external environments in which the organization competes. One or more of these approaches are often combined for more cost-effective treatment. The field studies for assessment of contamination comprised of detailed hydro-geological investigations which include geophysical investigations, borehole drilling, development of monitoring wells, followed by collection and analysis of existing field samples (dumpsite, subsurface soil and groundwater) are very critical for efficient handling of environmental pollution. It has been concluded that basic necessities for a healthy environment and public health include clean air, safe and sufficient water Safe and adequate food, safe and peaceful settlements, stable global environment in order to achieve excellent public health without soil pollution and groundwater contamination. Strategic approaches to remediation of contaminated soils include isolation, bioremediation, immobilization, toxicity reduction, physical separation and extraction.

1.0 Introduction

Sustainable use of the resources such as soil and groundwater and protection and conservation of their quality are key issues of developing countries and an enormous challenge for engineers and researchers on planet earth. Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds. Water pollution affects plants and organisms living in these bodies of water. In almost all cases

the effect is damaging not only to individual species and populations, but also to the natural biological communities. Strategic management involves the formulation and implementation of the major goals and initiatives taken by a company's top management on behalf of owners, based on consideration of resources and an assessment of the internal and external environments in which the organization competes. Water is a natural resource that is necessary for sustenance of life, ecological systems and a key resource to social and economic development (IPMA, 2013). Water is vital for sustainable socio-economic development as a strategic primary input playing a pivotal role in poverty alleviation through enhancing food security, domestic hygienic security, hydropower, industrial development, mining, navigation, and the environment for sustenance of ecosystems (Oyebode, 2019).

The stress on our water environment as a result of increased industrialization, which aids urbanization, is becoming very high thus reducing the availability of clean water. Polluted water is of great concern to the aquatic organism, plants, humans, and climate and indeed alters the ecosystem. The preservation of our water environment, which is embedded in sustainable development, must be well driven by all sectors (Inyinbor and Adebesin , 2018).

1.1 Basic Definitions

According to Marcella and Donna (2017), environmental health comprises those aspects of human health, including quality of life, that are determined by physical, biological, social, and psychosocial factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that can potentially affect adversely the health of present and future generations. "Soil Pollution" means the introduction into soil of substances, biological organisms or forms of energy that alter soil quality, impact the normal use of the soil or endanger public health and the living environment. Groundwater Pollution means the introduction into groundwater of substances, biological organisms or forms of energy that alter soil quality, impact the normal use of the soil or endangers public health and the living environment. Soil Pollution Monitoring Standards" means the determined pollutant concentrations at which soil pollution monitoring is required for the purpose of preventing soil pollution. Groundwater Pollution Monitoring Standards means the determined pollutant concentrations at which groundwater pollution monitoring is required for the purpose of preventing groundwater pollution. Soil Pollution Control Standards means determined soil pollution control limits to prevent and control the worsening of soil pollution. Groundwater Pollution Control Standards" means determined groundwater pollutant limits to prevent and control the worsening of groundwater pollution. Soil Pollution Remediation Goals" means the limit on pollutants set according to the purpose of soil pollution remediation.

1.2 Water Pollution and Soil contamination is not only in Nigeria

The issue of concern in this paper is not peculiar to Nigeria alone. Larger percentage of Cities in China suffers from some degree of water pollution, and nearly 500 million people lack access to safe drinking water. In addition to the acute problems of water pollution in developing countries, industrialized countries, continue to struggle with pollution problems as well. In the most recent national report on water quality in the USA, 45 % of assessed stream km, 47 % of assessed lake ha, and 32 % of assessed bay and estuarine square km were classified as polluted. Water is

Corresponding author's e-mail address: oyebodedare@yahoo.com

typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support a human use, such as drinking water. Natural phenomena such as volcanoes, algae blooms, storms and earthquakes also cause major changes in water quality and the ecological status of water. Climate change issues must be addressed in all ramifications for effective integrated water resources management. Civil Engineers put global changes into consideration in all construction, research, community development and consultancy work in order to achieve effective integrated water resources management (Oyebode, 2018).

Figure 1 indicates raw sewage and industrial waste flows across in a typical Nigerian community.

Figure 1: Raw sewage and industrial waste flows in a community in Nigeria

1.3 Aim and Objectives of this Study

The aim of this study is to obtain strategic approach for controlling soil and groundwater contamination in Nigeria. The objectives include protection of water resources in order to prevent environmental hazards, water stress, and other health related issues. The largest environmental challenge that Nigeria is facing today is water scarcity. Health protection is primary reason for environmental control in the whole world. Other reasons are protection of water resources, conservation of fishing zones, development of recreational areas. Figure 2 shows a typical anthropogenic water Turnover cycle.

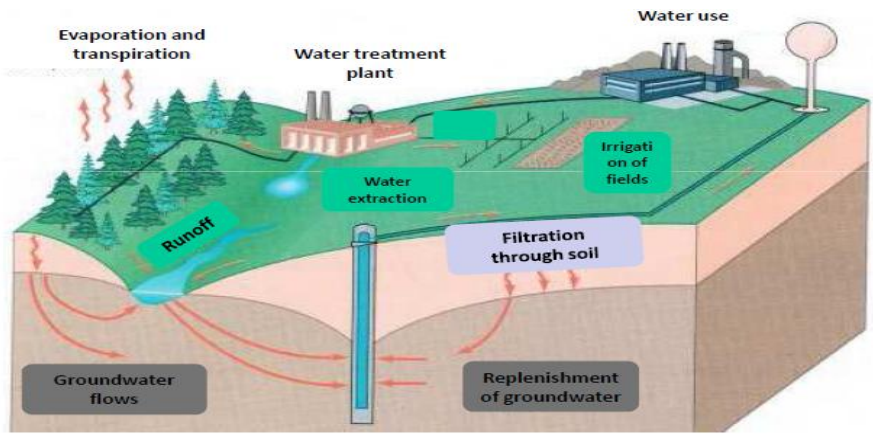

Figure 2: Anthropogenic Water Turnover Cycle (Oyebode, 2018)

Corresponding author's e-mail address: oyebodedare@yahoo.com

2. Literature Review

Water pollution is a major global problem which requires ongoing evaluation and revision of water resource policy at all levels (international level down to individual aquifers and wells).

Soil and groundwater pollution not only impact the normal use of the land but also may endanger nationals' health as well as the surrounding living environment. For this reason, apart from impairing the value of real estate on individual polluted land, pollution may result in external effects and affect the price of surrounding real estate.

A good knowledge of the remediation effect of pollution sites will contribute to assessing the feasibility, proper scale, and schedule of the remediation plan, for the purpose of more effectively allocating financial resources. In addition, the benefit analysis of pollution remediation plans can be taken as private sectors' investment incentive so as to encourage them to actively devote themselves to remediation and cooperate with local government's macro long-term urban redevelopment, which will contribute to the sustainable development of cities and resources.

Current water use already exceeds renewable supply. Many methods have been suggested to increase the sources of water supply; and one of these alternative sources is rainwater harvesting (RWH). (Sridhar and Coker, 2001).

Flowing surface water bodies have the natural capacities to purify themselves from the pollutions that come into them from external sources (Garg, 2006; Longe Omole, 2008).

Many of the community 's streams are highly polluted and disease-causing. Rainwater was thus a viable option considered in the design of a water supply scheme for the community (Coker, 1999).

Environmental law is a collective term describing the network of statutes, regulations and customary laws addressing the effects and human activity on the natural environment. The need for environmental laws in the country is as a result of the inappropriate use of the environment with regards to the ecosystem (Oyebode, 2018).

Currently, the above two water-pollution impacts are added to the vast other forecasted general effects of global warming, there's abundance of motivation to advocate action on global warming as element of an extensive approach to address water pollution. Lately, the World Bank and United nations agencies issued a series of publications to promote the development of water policy and strategy in developing nations. Serous guide lines were seriously gathered to be followed. It is strongly recommended – in these documents – to ensure that the development of national water policy and strategy to be performed by the concerned developing country itself with an uninterrupted assistance from the international agencies among the process. In fact, there are some conservative critics to this international policy in terms of the current and future understanding of water policy and strategy (Vajpeyi 1998).

2.1 Environmental and Economic Effect by Pesticides Use

Pesticide use raises a few environmental concerns. Over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, including non-target species, air, water and soil. Pesticide drift occurs when pesticides suspended in the air as particles are carried

Corresponding author's e-mail address: oyebodedare@yahoo.com

by wind to other areas, potentially contaminating them. Pesticides are one of the causes of water pollution, and some pesticides are persistent organic pollutants and contribute to soil contamination.

In addition, pesticide use reduces biodiversity, reduces nitrogen fixation, contributes to pollinator decline, destroys habitat (especially for birds), and threatens endangered species. Pests can develop a resistance to the pesticide (pesticide resistance), necessitating a new pesticide.

In most cases, treatment of the solid component of the waste was confined to dumping, followed by land application (Sangodoyin, 1992).

2.2 Causes of Groundwater Pollution

It is essential to highlight some causes of pollution. Causes of groundwater pollution include:

Increased urban waste water

Impact of industrial sectors

Soil contamination

Surface water pollution

Lack of groundwater protection legislations and standards

Lack of groundwater protection awareness

3. Strategic Approach

The method adopted is strategic approach through reconnaissance survey and stakeholders' consultation. One of the strategic approaches is to strengthen the prevention and control of groundwater pollution from soil in every sector and in all ramifications as indicated in Figure 3.

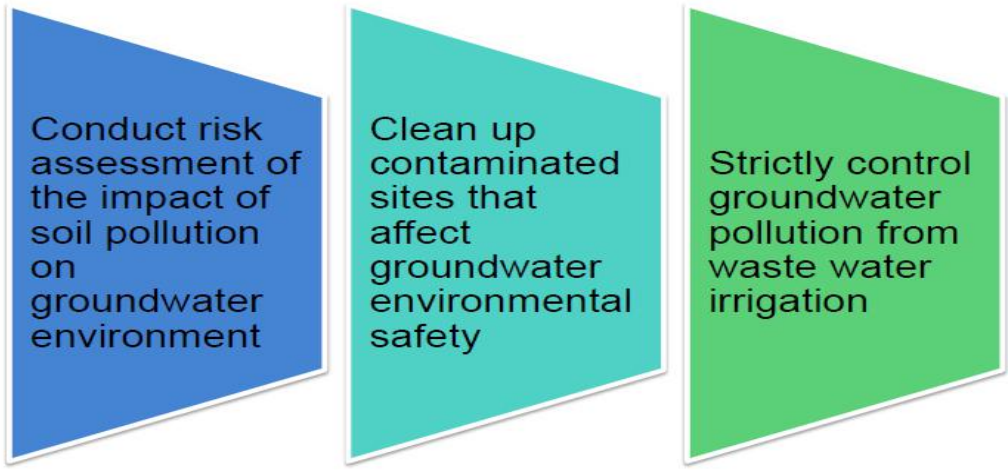

Figure 3: Strengthen the prevention and control of groundwater pollution from soil

Another approach is to conduct groundwater pollution remediation in a holistic and planned way as indicated in Figure 4.

Corresponding author's e-mail address: oyebodedare@yahoo.com

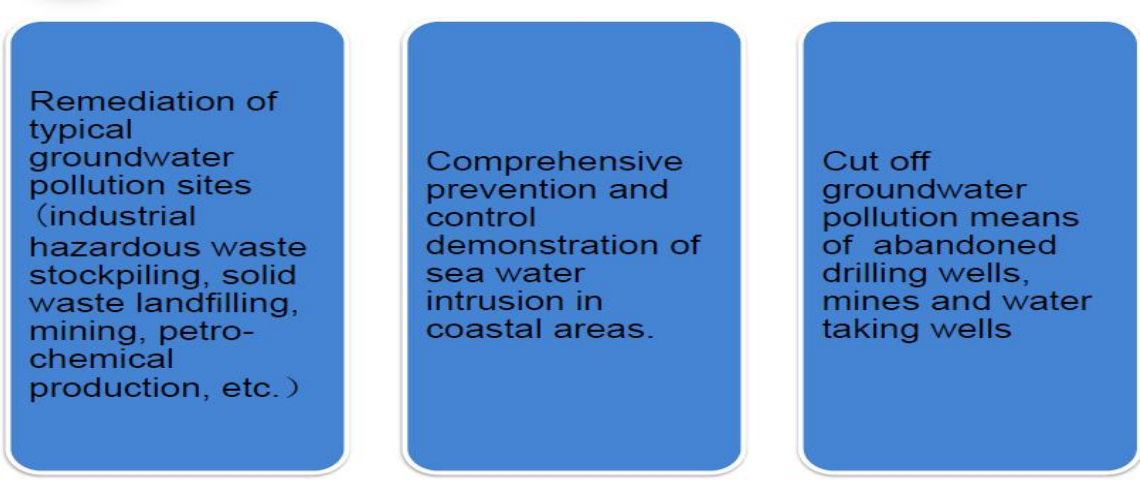

Figure 4: Conduct groundwater pollution remediation in a planned way

Also, we need to establish groundwater environmental monitoring, management, control and supervision system. Areas prone to petroleum hydrocarbon attack need special attention. Development of appropriate legislation to protect public health is very imminent. Figure 5 indicates ten essential Services for pollution control.

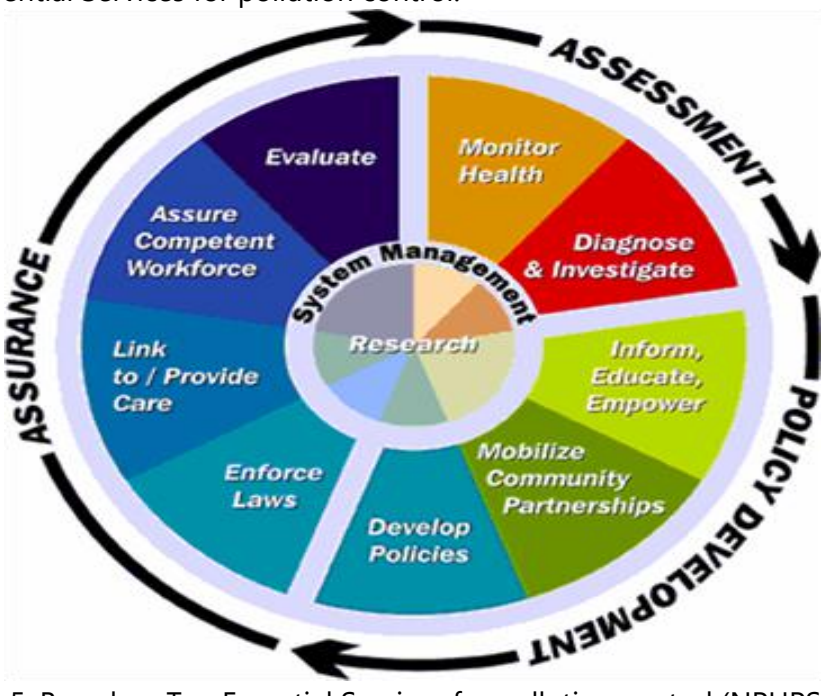

Figure 5: Based on Ten Essential Services for pollution control (NPHPS, 2014)

Water pollution can be controlled by treatment of water before leaving in water bodies, restoration of polluted water bodies, river training, water monitoring, effective action plan by government and copious stakeholders (Oyebode, 2018).

No successful remediation of the site can be done until this periodic release of the petroleum hydrocarbon product is stopped. Oil skimmer was used in the skimming off the pure phase hydrocarbon from the monitoring wells within the pilot test area (Ola, et al. 2017). The oil skimming technology was adopted to remove hydrocarbon contamination from groundwater without the pumping of groundwater with the contaminant in Baruwa Lagos State as indicated in Figure 6.

Corresponding author's e-mail address: oyebodedare@yahoo.com

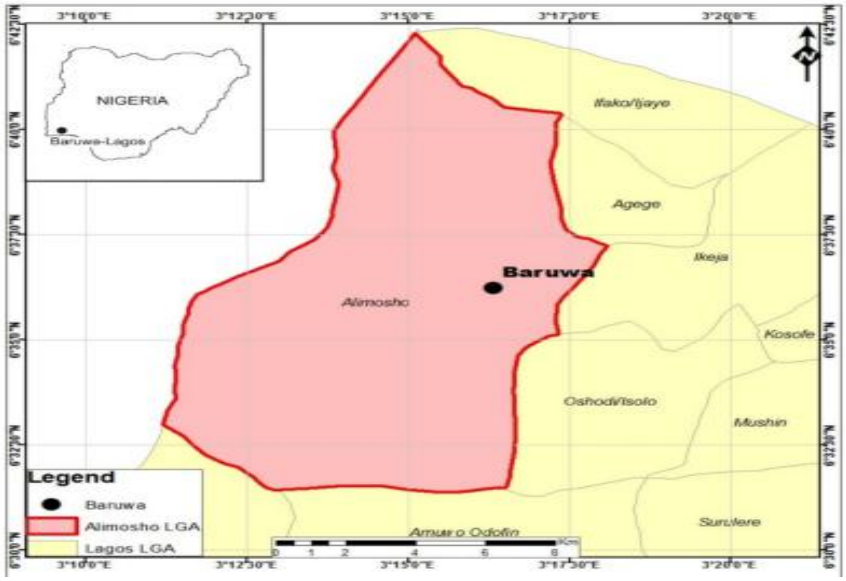

Figure 6: The Map of Baruwa-Lagos: Case study of Contaminated Site in Nigeria (Oyebode, 2018).

4.0 Strategic handling of Soil Pollution

Soil pollution is defined as a phenomenon characterized by the loss of structural and biological properties by the soil layers as a result of numerous human and natural factors, such as wind, deforestation, chemical use, among others, etc. Soil can become contaminated in many ways. Chemicals, like herbicides and pesticides, are major polluters; oil dumps, landfills, and industrial wastes can also wreak havoc. Pollution may be defined as an undesirable change in the physical, chemical and biological characteristics of air, water and soil which affect human life, lives of other useful living plants and animals, industrial progress, living conditions and cultural assets. A pollutant is something which adversely interferes with health, comfort, property or environment of the people. Soil contamination or soil pollution is caused by the presence of human-made chemicals or other alteration in the natural soil environment. This type of contamination typically arises from the failure caused by corrosion of underground storage tanks (including piping used to transmit the contents), application of pesticides, oil and fuel dumping, disposal of coal ash, leaching of wastes from landfills or direct discharge of industrial wastes to the soil (Mohammed et al, 2013).

Water resource management is very essentials for handling development of water bodies for future, protection of available water bodies from pollution, over exploitation and for prevention of dispute. High gross domestic product (GDP) per capita, sustainable water resource management, high average incomes, well developed infrastructure, low unemployment, low levels of crime and corruption are crucial parameters for national development. (Oyebode, 2018)

4.1 Result from Niger Delta contamination

There is a lot of surface water pollution and soil contamination in the study area as indicated in Figure 7.

Corresponding author's e-mail address: oyebodedare@yahoo.com

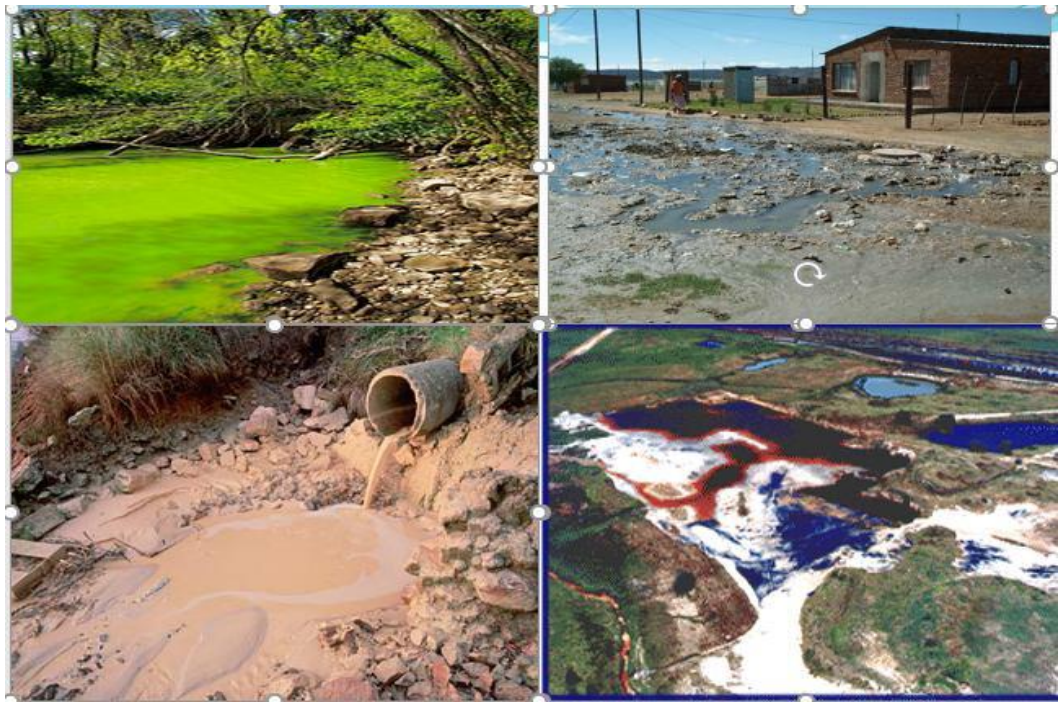

Figure 7: Surface water pollution and soil contamination in Niger Delta Area (Oyebode, 2019)

Soil pollution is caused by the presence of chemicals or other alteration in the natural soil environment. Resulting in a change of the soil quality is likely to affect the normal use of the soil or endangering public health and the living environment. Soil is upper layer of earth crust, contains organic matter and other minerals. Dumping of wastes, garbage, rubbish like glass, plastics, metallic cans, papers, cloth rags, containers causes soil pollution. Other causes include discharge of Industrial wastes, fly ash from Thermal power plants, sewage sludge and radioactive wastes, fertilizers and pesticides on soils. Effects are reduction of soil productivity, adverse effect on soil flora and fauna, sludge contains worms, bacteria and pathogens that are detrimental to public health, radioactive wastes enter food chain, untreated products and wastewater before discharge. The application of sewage sludge can either stimulate soil microbial activity, due to an increase in available carbon and nutrients, or inhibit activity, due to the presence of heavy metals and other pollutants (Baath, 1989).

Role of an Individual in Pollution prevention includes thinking globally and act locally, use eco-friendly products, use rechargeable batteries, no to excess pesticides, chemicals, paints, solvents, use of less or only required quantity of resource, planting of trees (local species) and application of 3 R'S- Reduce, Reuse, Recycle (Oyebode, 2018).

Table 2 highlighted screening standards for assessing the contamination levels while Figure 7 gives the Pollutant Source.

Corresponding author's e-mail address: oyebodedare@yahoo.com

Table 2: Screening standards for assessing the contamination levels (Compounds relevant to the studies)

S.No.	Name of the compound	Screening Standards (USEPA- DEC.2009)	
		Industrial Soil (mg/kg)	Ground water protection (mg/kg)
1	Carbaryl	62000	3.3
2	Aldicarb	620	0.09
3	Alpha Naphthol(nearest is Naphtha)	31000	NA
4	Alpha HCH	0.27	0.000062
5	Beta HCH	0.96	0.00022
6	Gama HCH(Lindane)	2.1	0.00036
7	Technical HCH	0.96	0.00022
8	Chloroform	1.5	0.000053
9	Toluene	45000	1.6
10	Chlorotoluene	20000	0.71
11	Dichloro benzene	9800	0.36
12	Trichloro benzene	4900	0.087
13	Elemental mercury	34	0.03

From Figure 7 and as shown by Oyebode (2018) on Pollutant Source Pathways, the following could be identified.

Arsenic Poisoning

High levels of arsenic above the permissible levels of 50 parts per billion (ppb) are found in the alluvial plains of Ganges covering six districts of West Bengal.

Arsenic contamination of drinking water causes a disease called arsenics, for which there is no effective treatment.

Arsenic contamination is by far the biggest mass poisoning case in the world putting 20 million people from West Bengal and Bangladesh at risk though some other estimates put the figure at 36 million people. A lot of cost of emission controls is needed in areas of high pollution. The law of diminishing return is applicable to the relationship of pollutant emissions and cost of emission controls as shown in Figure 8.

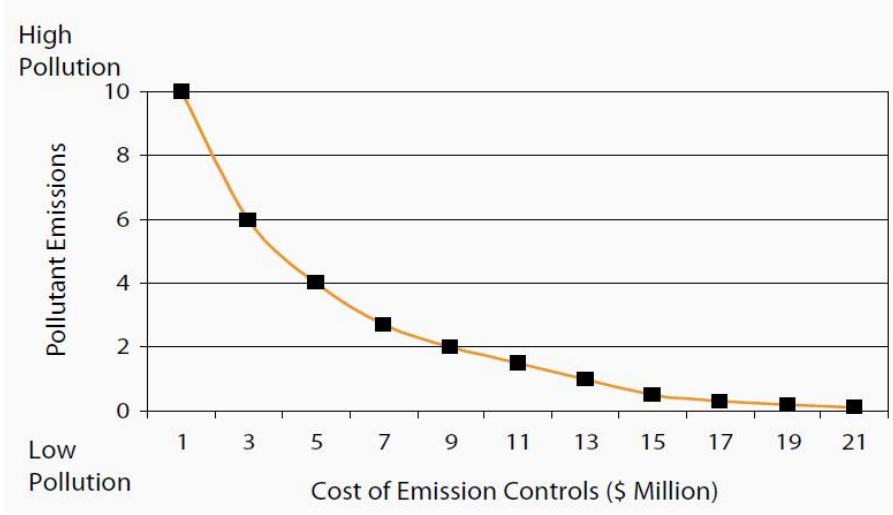

Figure 8: The Law of Diminishing Return

Corresponding author's e-mail address: oyebodedare@yahoo.com

5. Conclusions

It has been established that groundwater environmental monitoring, management, control and supervision system is essential for pollution abatement and contamination reduction. Prevention and control of groundwater pollution from soil in every sector need to be strengthened. No successful remediation of the site can be done until this periodic release of the petroleum hydrocarbon product is stopped. It has been concluded that strategic approach for controlling soil and groundwater contamination in Nigeria is very critical for environmental sustainability. Strategic approaches to remediation of contaminated soils include isolation, bioremediation, immobilization, toxicity reduction, physical separation and extraction.

Peaceful settlements, stable global environment and clean air are essential in the achievement of excellent public health without soil pollution and groundwater contamination. General approaches to remediation of contaminated soils include isolation, immobilization, toxicity reduction, physical separation and extraction. One or more of these approaches are often combined for more cost-effective treatment. A few of the available technologies have been demonstrated in full-scale applications and are presently commercially available.

Necessities for a healthy environment and public health include clean air, safe and sufficient water Safe and adequate food, safe and peaceful settlements, stable global environment in order to achieve excellent public health without soil pollution and groundwater contamination.

There is a desire and concern for the protection and management of groundwater quality. Water quality analysis of groundwater contains determination of its physical, chemical and organic characteristics, from that its suitability for drinking, irrigational, industrial and different purposes. Environmental health, safety and security awareness and development of necessary legal framework can avert groundwater pollution in Nigeria.

Recommendations

The following recommendations were made for effective and helpful impact on the environment:

Nigerian Society of Engineers and other engineering professional bodies must be assisted by governments, organization, stakeholders and every sector for revitalization of Nigerian environment.

Holistic preventive measures of water pollution and soil contamination by government, private companies, engineers, environmental experts and individuals is very essential..

It is recommended that the contaminated wells should be immediately sealed so as to prevent use of water from these wells for any purpose by the populace.

Measures to prevent water pollution are to conserve and protect water quality - in terms of its use reduction and disposal, wastewater treatment, technical changes and recycling. Practice of waste to wealth and health needs to be encouraged. Strengthening of groundwater monitoring and management systems should be adopted in all ramifications.

It is essential to establish groundwater pollution risk prevention system. Scientific sustainable remediation measures need to be developed, adopted for effective overall environmental monitoring and management.

Corresponding author's e-mail address: oyebodedare@yahoo.com

Oil industries need to embrace spatial techniques for effective monitoring of pipeline, Environmental Impact Assessment facility index mapping, Spill contingencies planning and environmental data-base management to avoid groundwater contamination and to achieve social equity, economic sustainability and environmental sustainability.

Government, water development agencies, environmental health scientists, engineers and researchers must ensure that there is proper funding as well as right procedures in the planning and execution of water resource management contracts.

Strategic approach such as sensitization of the public on the impact of soil and groundwater contamination on the public health in the community should be adopted.

Special consideration for pollution and contamination amelioration by Engineers and other experts in construction fields are essentials.

Supervision, assistance and approval of soil, sediment and groundwater pollution prevention, monitoring and remediation work by special municipality, county or city competent authorities are crucial for public health and reduction of pollution.

Drafting, deliberation and interpretation of soil, sediment and groundwater pollution remediation laws and regulations are very crucial

Substantial capacity building for groundwater projects is essential for environmental monitoring and supervision is required in Nigeria,

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Corresponding author's e-mail address: oyebodedare@yahoo.com