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Control Measures on Groundwater Pollution through Leakages of Underground Storage Tanks of Filling Stations in Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author OEO designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors HOS and SOA managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Background: Groundwater pollution from leakages of Underground Storage Tanks is a global issue and has been significantly controlled and maintained by many developed countries in the last 30 years. The knowledge and practices used in containing this environmental issue can also be applied locally in Nigeria.
Methods: This paper reviewed the environmental policies and strategies put in place by the United States of America and the statutory regulations in Nigeria to identify the possible causes of pollution from leaking underground storage tanks within the country in order to recommend applicable preventive and control measures.
Results: Findings showed there are lots of regulations and laws to protect environmental resources in Nigeria which has led to establishment of different ministries, departments and agencies of government for implementation yet, a number of shortcomings can be traced to its inability to efficiently control leaking underground storage tanks in filling stations nationwide.

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Conclusion: However, necessary recommendations were made which could be applied by implementing minor preventive measures and procedures that will significantly curb this menace as achieved in other developed nations of the world.

Keywords: Groundwater; Underground Storage Tanks (USTs); filling stations; environmental regulations.

1. INTRODUCTION

Reported cases of groundwater pollution is both a global and local issue as evident in a lot of publications [1], although most were attributed to anthropogenic activities [2,3]. Some of the sources are seepages from waste disposal sites, sewage, waste waters from abattoirs and industries, agricultural and pesticides runoffs and leaking underground storage tanks among others [4,5].

The Underground storage tanks (USTs) is defined by the United States Code of Federal Regulations [6] as tanks and any underground piping connected to the tank that has at least 10 percent of its combined volume underground. These tanks are used to store varieties of chemicals or hazardous substances especially gasoline and other notable petroleum derived products, at both urban and rural areas [7]. Hence, these tanks leaking poses great threat to the environment because of the contents stored in it such as chemicals, lubricants, petroleum and organic mixtures.

The problem arising from Leaking Underground storage tanks (LUSTs) tends to be a global issue because USTs are majorly used in filling stations for storing petroleum products and these stations are located everywhere (both rural and urban) due to the dependency of the products stored in it [8,9]. Reports of LUSTs has been properly documented and managed in the United States over the years as these environmental menace has been reduced and cleanup/remediation activities has been successfully carried out afterwards [8,9].

Other international incidents of LUSTs pollution on groundwater quality include: PAHs and BTEX contamination of Groundwater from Gasoline Stations as reported in Rio de Janeiro City, Brazil [10], contamination by benzene due to diesel and gasoline leaks at a gas station in Natal / Brazil [11], BTEX contamination of Bengaluru aquifers, Karnataka, India [12].

In Nigeria, some recent studies which reported cases of filling stations pollution to environmental media include: Soil pollution in Benue State [13], heavy metal and aromatic hydrocarbon pollution of soil in Ibadan [14], groundwater quality in Ilorin metropolis [15,16].

Some identified sources of possible release of pollutants from USTs into the environment includes operational errors, pipes failure, tank leakages, improper installations, overfills, loose fittings, corroded USTs etc. [17,18]

Hundreds of thousands of polluted groundwater sources by contents of USTs has been identified in the United States of America (USA), United Kingdom (UK), Europe and across the globe, where successful application of various policies and regulatory frameworks yielded a positive result, hence, Nigeria can also employ similar ideas locally to control this silent crisis. This study therefore reviews the existing status of the preparedness in the protection of groundwater resources from pollution at filling stations across the country to suggest solutions to some available lapses.

2. LITERATURE REVIEW

The location of filling stations across Nigeria is primarily stimulated by the high demand of petroleum products such as gasoline, diesel and kerosene, which are sold at the stations. These products are required in day-to-day activities of an average man as gasoline and diesel is used as fuel in automobiles for transportation, operation of machines as well as electricity generation to run businesses, kerosene used as fuel for cooking etc. [19]. Hence, promoting the construction of filling stations at close proximities to end users nationwide.

Underground Storage tanks are used as the major storage facilities for these petroleum products in the filling stations, and reports showed that leaking tanks from these stations are possible sources of release for pollutant like benzene, toluene, ethyl benzene, p-xylene

(BTEX), polycyclic aromatic hydrocarbon and other toxic substances into the environment [4].

2.1 Related Legislative Framework in United States of America

According to Simon and O'neill in 1988, about 90% of water supply pollution remediating sites were traced to LUSTs across the United States [20].

Till the enactment of the Resource Conservation and Recovery Act (RCRA) by the United States congress in 1976, LUSTs among other hazardous waste were improperly disposed [21], an environ-vigilant call that instigated a heightened regulation after the Love Canal illegal dumping of hazardous waste were the LUST incidences reported by CBS at Colorado and New York where gasoline leaked into nearby basements [22].

Prior to the inclusion of Subtitle 1 in the Resource Conservation and Recovery Act (RCRA) of 1976, that permits the Environmental Protection Agency (EPA) to develop regulations that protects man and the environment from the pollution posed by leaking USTS, there were a lot of groundwater resource pollution from these sources across the country [23]. the Act which birthed both Federal and State UST programs significantly reduced the risk of leakages and release of pollutants by implementing release-prevention and leak-detection requirements establishing improved design, installation, and operational technical standards [24].

For example, in 1988 the Federal UST regulations were endorsed and some standards set by the regulation in controlling these issues include pressurized tightness tests for USTS and pipes, monitoring of installations and accessories, upgrade and replacement of aged tanks, report of leaks and so on. These regulations and increased oversight plus reforms over the years helped in identifying, registering and regulating USTS which has achieved a reduction in the pollution problem posed by LUSTS and aided clean-up activities [25].

2.2 Related Legislative Framework in Nigeria

In Nigeria, there has been a lot of environmental and public health law protecting the land, water and air against pollution as far back as during the colonial era, examples were The Criminal Code Act of 1916 [26,27] and The Public Health Act of 1917 [27,28], where others more related to the Petroleum sector were introduced after the post-independence oil boom involving activities that dealt with more of exploration and upstream regulations e.g. The Mineral Oils (Safety) Regulation of 1963 [29], The Oil Pipeline Act of 1965 [30], The Petroleum Regulations 1967 [31], The Oil in Navigable Waters Decree of 1968 [32], The Petroleum (Drilling and Production) Regulations of 1969 [33], and The Petroleum Refining Regulations of 1974 [34], basically to issue licenses/permits and establish guidelines with little impact on pollution control so increasing cases of pollution in the environment until the Department of Petroleum Resources in 1981 issued an interim Guidelines concerning the monitoring, handling, treatment, and disposal of effluents, oil spills and chemicals, drilling muds and drill cuttings by leases/oil operators [35,36].

A major turn-around which stimulated a heightened awareness and public involvement into environmental protection laws and regulations was the incident of toxic waste dump at Koko in 1988 [37,38], which immediately led to enactment of the Harmful Wastes (Special Criminal Provisions) Decree and the establishment of the Federal Environmental Protection Agency (FEPA) from its Act later metamorphosed to form majority of the key role players in present day environmental management in Nigeria [38,39].

Some recently constituted laws and regulations relating to activities that involves protection of the environment and formation of parastatals, agencies and departments include; The Federal Ministry of Environment Act, National Environmental Standards and Regulations Enforcement Agency (NESREA) Act of 2007 [40] authorized to enforce environmental laws and ensure compliance in all sectors, also to set effluent limits, set air, water and soil quality standards, and the Environmental Impact Assessment Act (EIA) of 1992 [41] that assesses the potential negative environmental impacts that might arise from proposed projects, another relevant legislation relating to petroleum products pollution in Nigeria is the National Oil Spill Detection and Response Agency (NOSDRA) Act of 2006 [42] which covers issues relating to oil-spill containment, recovery, and remediation plans [38,39], and the most recent Petroleum Industry Bill (PIB) [43]. Amidst all these regulations, the statutory regulator for downstream petroleum operations with regards

to environmental policy in Nigeria is the Department of Petroleum Resources (DPR) [36]; their duty involves developing various environmental guidelines and standards that extends to activities in a filling station till date.

3. IDENTIFIED CAUSES OF POSSIBLE UST LEAKAGES IN NIGERIA

Unfortunately, with the robust legislation to protect our environment and regulatory agencies, it is still obvious a lot has to be done in protecting the groundwater resources from pollution across these proliferating filling stations all over the country. Some identified lapses that needs attention are:

3.1 In Relation to Legislation

DPR which sets up environmental standards and guidelines has stressed more emphases to licenses/permit issuance and attention on the operations and control in the petroleum industry than reviewing their negative impacts to the environment [44].

EIA which is one of the primary requirement in the DPR guideline for approval to construct and operate a filling station is applicable only to USTs of capacities over 270,000 L which in essence does not affect major low-capital independent marketers of lesser USTs volumes allowed by the same regulation to operate as they meet the condition of providing a minimum of three (3) USTs (one for diesel, petrol, and kerosene respectively) with an average of 100,000 – 250,000 L that makes up of majority of the stations around us [45,46].

NOSDRA activities till date focuses more on oil spills from activities relating to the upstream and offshore sector in the petroleum industry than cases arising from the downstream most especially filling stations [42].

NESREA the most prominent environmental watchdog in the country is handicapped as the act that formed it restrict its autonomy to all sectors in the country except the oil and gas sector [38].

Lack of synergy and conflicts of interest among key players in the environmental sector affects the efficiency of mitigating this menace in situations such as the overlaps and duplication of functions by Federal and State Ministries of Environment on related issues arising from a location of political influence.

Also, poor enforcement of environmental laws by regulatory agencies can be attributed to inadequate funding, lack of technical know-how, shortage of staff, limitation in mobility to cover a wider area, political influence among others.

Other related factors that influences leakages from USTs at filling stations include;

3.2 Types and Ages of Tanks

Majority of the oil tanks used nationwide are single wall steel tanks which has been continuously used without replacement for many years. Record has it that old single wall USTs are one of the highest sources of groundwater pollution globally [4].

3.3 Limited Use of Preventive Technology and Engineering Measures

Most stations in the country lacks modern technological intervention or engineering measures to prevent, monitor and control leakages as they still depend on using dipping stick to measure the volume of petroleum products in their storage tanks in detecting leakages, no automated spill detection systems, very few monitoring wells, no overfill devices and corrosion prevention measures in place to protect the environment.

3.4 Lack of Data

Without data, information cannot be processed. Significantly, there is no accessible records of numbers of USTs nationwide, nor information concerning them such as age, location, decommissioning history, leak tests information etc. Also, water sources such as records of municipal wells, and boreholes both private and public are not kept by the appropriate bodies.

4. RECOMMENDABLE SOLUTIONS FROM DEVELOPED COUNTRIES

As mentioned earlier, a country like the United States who had similar experience of groundwater pollution from LUST in filling stations undertook some measures which are practicable in Nigeria too and can help in preventing this menace. Examples of these measures are:

4.1 Setting up an UST Legal System

If the aforementioned nations could set up a legal framework solely for laws and regulations

relating to pollution control from USTs and gas stations such as United States Environmental Protection Agency (USEPA) formed Office of Underground Storage Tanks (OUST) in 1985 (a federal body) under the provision of the Resource Conservation and Recovery Act (RCRA) [47] with the sole responsibility to protect the groundwater resources from contamination of LUSTs [9]. To relieve the challenges of covering a wider area effectively and maximizing sufficient resources both in funds and personnel, States were given the autonomy to run their own regulations with limited Federal influence since conditions such as geological, weather, financial etc., varies across States [9,47]. In this way, a country like Nigeria with reports of over 26,000 retail stations as at 2006 by Petroleum Product Pricing Regulatory Agency [38,48] and a total of 31,220 functioning stations with storage capacity of 4,800,470,724 Litres for petroleum products in 2016 [49] requires a more stringent constituted body that will primarily be focused with USTs monitoring, leaks prevention, early detection through routine inspections and clean up. This body could make use of environmental health officers and other task forces in conjunction with the existing legislations and regulators.

4.2 Preventive Measures and Standards

Success stories of the significant fall in rates of LUSTs in US, UK, Europe and Asia as reported in literatures [4,8,9] which resulted from the enforcement of certain preventive and control measures in accordance to regulations in protection of the groundwater resources are practicable here. Examples of such control measures are:

4.2.1 Unlike the single-wall corrodible steel fabricated USTs presently used, a non-corrodible material like the Fiberglass Reinforced Plastics (FRP) or Glass Reinforced Polyester (GRP) should be in fabricating all USTs nationwide, and if that cannot be meant compulsory corrosion protection mechanism should be put in place for double-walled steel USTs nationwide. In implementing this, a time frame should be issued for all existing tanks to be replaced or upgraded as age greatly influences leakage rates in tanks.

4.2.2 To avoid spills, all filling stations should install automated spills and overfill alarm gadgets to place of the regular dipping stick used to measure the depth of petroleum products in detecting leaks in the tank.

4.2.3 For groundwater monitoring, compulsory drilling of 3-4 monitoring wells positioned at the edges of the buried USTs is advised within a short time frame for existing stations. Followed by a timed routine inspection by regulated bodies, researchers, scientists or interested individuals in successfully monitoring the groundwater quality in that environment with data published for access to general public.

4.2.4 Proper record keeping of information such as dates of repairs, leak tests and tightness tests in pipes, inspection by regulators etc., be made publicly available at all stations.

Other recommendations to address the issue includes:

4.3 Community Involvement

A better knowledge of geological, hydrological and environmental conditions and demands is readily available among the locals of an environment, this knowledge hence could be applied in prevention and control of USTs regulation in a community. In Nigeria, a country with diverse culture, language and ecological biome, it is advised significant member of the community has a role and stake in regulating filling stations hence this will control pollution as an increased commitment will promote the protection of the groundwater resources (an environmental justice perspective i.e. NIMBY – Not In My Backyard).

4.4 Distancing USTs from Water Sources

Another effective way to prevent LUSTs pollution of groundwater resources is the proximity restriction of a notable distance between USTs and water sources, these can be governed by the geological and hydrogeological characteristics of the environment such as sand and gravel environment are more porous and permeable than clayey environment.

For instance, the State of Maine in United States based on its own environmental and geological characteristics in 2001 passed an act to protect its water sources from oil contamination from USTs, some of the regulations prohibits

installation of USTs within 300 ft of any private wells except if the well supplies water for the UST business, or within 1000 ft of a community or school water source, or over a high yielding sand/gravel aquifer [24]. Also, Olufayo [50] mentioned that one of the guidelines for location of filling stations by DPR [51] is maintaining a minimum distance of 30 m between USTs and water sources but this can even be further extended in vulnerable soil zones.

4.5 Preventive Measures and Standards

Since there are regulations to protect the environment, adequate inspections, effective enforcement, increasing staffing and training nationwide and funding should be encouraged. In solving the problem of lack of fund for regulators and environmental monitoring activities, at present there are financial allocation for such activities sponsored by the Ecological Fund [37] but if not accessible due to bureaucracy, regulatory offices assigned can implement a minute amount as returns on petroleum products sold as tax revenues or, the imposing fines on polluters (Polluters' Pay Principle).

5. CONCLUSION

Leaking underground storage tanks from filling stations releases contaminants into groundwater which poses great health risk but with simple and achievable environmental protection and control practices we can sustain the environment for coming generation and minimize pollution of the available resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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