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Examination of Water Quality in Agbarho, Delta State: Organic Contaminants and Microbial Presence

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ABSTRACT

The evaluation of surface and groundwater sources near the General Hospital plant in Agbarho, Delta State took place in 2024. Sixteen (16) water samples were gathered from eight locations marked (S1, S2, S3, S4, U1, U2, U3, and U4) in the study area. These samples were tested for organic pollutants using Gas Chromatography Mass Spectrometry (GC-MS) and for bacteriological contamination. The analysis identified xylene, ethylbenzene, butylated hydroxytoluene, and toluene in the samples through GC-MS. The bacteriological tests revealed that the total coliform count varied from 2×104 (Cfu/ml) to 31×104 (Cfu/ml), indicating faecal contamination. The results exceeded the World Health Organization (WHO) standards for aquatic life and drinking water, suggesting inadequate support for aquatic ecosystems. This study indicates that hospital waste and other human activities negatively impact water quality. Therefore, it is recommended that General Hospital, Agbarho, Delta State, strictly adhere to government regulations on waste disposal and management.

Keywords: Bacteriological, Agbarho, GC-MS, General Hospital, organic contaminant, surface, ground

1.0 INTRODUCTION

Contaminated water sources have serious effects on human health and the environment (Peterson et al., 1971). Recently, there has been significant interest in the role of water quality in human health. In the developing world, 80% of diseases are linked to poor drinking water and unsanitary conditions (Olajire and Imeokparia, 2001; Chung et al., 2007). Wastewater from hospitals is commonly known as hospital waste, which is a specific type of waste that includes all biological and non-biological materials discarded from hospitals or healthcare centers, not meant for reuse (Oyeleke et al., 2008). Hospital effluents contain both organic and inorganic materials, including organic pathogens, toxic chemicals, radioactive substances, and heavy metals (Obruche et al., 2025). The presence of these substances, especially in large amounts, can pose serious problems for the community (Omoruyi et al., 2011). The volume of wastewater produced by hospitals varies from one facility to another. Tsakona et al. (2006) estimated that the average wastewater production in hospitals is about 1000 liters per person per day. The main health risks associated with hospital wastewater for both terrestrial and aquatic ecosystems include the contamination of surface and groundwater, the buildup of toxic non-biodegradable hospital waste, the accumulation of heavy metals, unregulated landfills, and poor waste sorting practices. The toxic substances released into water bodies can accumulate through the food chain (Odiete, 1999; Itodo et al., 2021).

Hospital waste is the waste produced, thrown away, and not meant for reuse in hospitals (Heen, 1999). It consists of both liquid and dissolved materials created in the hospital setting. The classification of hospital waste is as follows:

- General waste: This mainly includes non-hazardous items like kitchen scraps, paper, and plastic.

- Infectious waste: This type contains pathogens (bacteria, viruses, parasites, or fungi) in enough amounts to potentially cause illness in vulnerable individuals, such as cultures and stocks from lab work, and waste from surgeries and autopsies involving patients with infectious diseases (e.g., tissues and materials that have been in contact with blood or other bodily fluids).

- Pathological waste: This includes tissues, organs, body parts, human fetuses, animal carcasses, blood, and bodily fluids. Recognizable human or animal body parts fall under this category and are also referred to as anatomical waste.

- Sharps waste: Sharps are objects that can cause cuts or punctures, such as needles, hypodermic needles, scalpels, other blades, knives, infusion sets, saws, broken glass, and nails. Regardless of infection status, these items are typically viewed as highly dangerous.

- Pharmaceutical waste: This consists of expired, unused, spilled, and contaminated pharmaceutical products, drugs, vaccines, and sera that are no longer needed and must be disposed of properly. It also includes discarded materials used in handling pharmaceuticals, like bottles or boxes with residues, gloves, masks, connecting tubing, and drug vials.

- Genotoxic waste: This type is extremely hazardous and may possess mutagenic, teratogenic, or carcinogenic characteristics. It poses significant safety risks both within hospitals and after disposal. Genotoxic waste can include certain cytostatic drugs, vomit, urine, or feces from patients treated with cytostatic drugs, as well as chemicals and radioactive substances.

- Chemical waste: This type of waste includes discarded solid, liquid, and gas chemicals, often from diagnostic and experimental activities, as well as from cleaning and disinfecting tasks.

- Radioactive waste: This waste contains radioactive materials and is typically a by-product of nuclear power generation and other uses of nuclear technology, including research and medicine. It poses risks to life and the environment and is subject to regulation. It encompasses solid, liquid, and gas wastes that are contaminated with radionuclides from in-vitro analysis of body tissues and fluids. Radionuclides undergo spontaneous disintegration, known as "radioactive decay," releasing energy and often forming new nuclides.

Biological contaminants mainly come from animal and human waste. The amount of organic matter and bacteria is assessed by coliform count (Ogwuche & Obruche, 2020). BOD measures the oxygen needed to break down organic matter in a sample through microorganisms in wastewater. It is the most common indicator of organic pollution in wastewater, surface water, and groundwater (Bhatia, 2009). Microorganisms consume oxygen to decompose complex organic molecules in aerobic processes. Coliform count helps identify harmful bacteria in water by detecting E. coli, a bacterium found in feces. If E. coli is present, it suggests potential contamination by other harmful bacteria. Chemical oxygen demand indicates the oxygen needed for the complete oxidation of carbon (IV) oxide and water from organic matter in water, wastewater, or effluents. Pollutants cause various health issues like cancer, neurological disorders, chronic bronchitis, and asthma (Kump, 1996). They are divided into two categories: primary pollutants, which are harmful in their original form, and secondary pollutants, which are created through chemical reactions from less harmful substances. Most pollutants enter the environment through emissions or discharges into water bodies, coming from specific sources like factories and hospitals, or from diffuse sources like agricultural runoff. The impact of a pollutant released into the environment is influenced by its toxicity, how long it lasts, how it spreads, its chemical reactions including breakdown, its potential to accumulate in food chains, and how easily it can be controlled. Each type of pollution follows a pathway that includes the pollutant, its source, the transport medium (air, water, or land), and the target ecosystem (Holdgate, 1979).

Groundwater and surface water pollutants can be classified as Organic Pollutants. These organic pollutants can be further divided into:

- Disease-causing wastes: These consist of pathogenic microorganisms that can enter water through sewage and other waste, posing serious risks to public health. These microbes, mainly viruses and bacteria, can lead to severe water-borne diseases like cholera, typhoid, dysentery, polio, and infectious hepatitis in humans.

- Synthetic Organic compounds: These are human-made substances such as pesticides, detergents, food additives, pharmaceuticals, insecticides, paints, synthetic fibers, elastomers, solvents, plasticizers, plastics, and other industrial chemicals. These chemicals can enter the hydrosphere through spills during transport and use or through the intentional or accidental release of waste from manufacturing facilities.

- Many of these chemicals can be harmful to plants, animals, and humans. Certain bio-refractory organics, like aromatic chlorinated hydrocarbons, can create unpleasant smells and tastes in water, even in small amounts, making it visually unappealing. Nondegradable substances, such as alkyl benzene sulphonate from synthetic detergents, often result in lasting foam.

- Sewage and agricultural runoff: Directly dumping sewage or leaking from broken sewers into lakes, ponds, or streams contaminates water. Leachate from farms, which contains nitrates, phosphates, and potash, seeps down with water and enters the aquifers below, threatening groundwater. This leachate also provides nutrients for plants, which can encourage the growth of algae and other aquatic plants in the water body.

- Oil: Oil pollution can occur due to spills from cargo tankers at sea, losses during offshore oil exploration and production, accidental fires on ships and tankers, and leaks from oil pipelines that cross waterways and reservoirs. Oil pollution decreases the dissolved oxygen in water (Owuna, 2012).

The purpose of this study is to identify the organic pollutants (methylene chloride, xylene, butylated hydroxytoluene, ethyl benzene, toluene, and formaldehyde) and the colony-forming units found in surface and groundwater sources in the area of study.

2.0 MATERIALS AND METHODS

2.1 Study Area Overview

This research focuses on both surface and groundwater near the general hospital in Agbarho, Delta State. The area is located between longitudes 3°E-9°E and latitudes 4°30’N-5°21’N in the Niger Delta, which is known for its oil resources (Obruche et al., 2019). Agbarho experiences frequent rainfall, with annual precipitation between 3500 and 4000 mm (Obruche et al., 2023). The combination of high rainfall, humidity, and river discharge during the wet season, along with the low, flat landscape and poorly drained soils, leads to significant flooding (Obruche et al., 2019). The climate in Agbarho is tropical, with a rainy season lasting from eight to ten months, typically from February to late November, interrupted by a break in late July or August (known as the August break). The dry season extends from late November or early December to late January, sometimes into early February, with occasional light rain in February (Obruche et al., 2018; Ekpo et al., 2024).

2.2 Method of Sampling and Sample Collection

A random sampling method was used to choose the sampled locations (APHA, 2005; WHO, 2011, Obruche et al., 2022). A total of 10 samples were gathered over four months, from August to December 2024, from eight different sites in the study area. Surface water samples were taken from four points labeled S1, S2, S3, and S4. The samples were collected after agitating the water body in aerated vessels with a water sampler, fetching 500cm3 of surface water for analysis from each point (Wyasu, 2011). Clean containers were used to collect surface water samples for organic pollutant analysis, each with a volume of 500cm^3

Ground water samples were taken from four points U1, U2, U3, and U4. These points were hand-dug wells located in a small farming community within the study area. A 500cm3 ground water sample was collected from each point and transported to the laboratory within two hours of collection.

2.3 Analysis and Characterization

To assess water quality, including organic parameters and microbial content, standard methods for Water and Wastewater analysis were followed (APHA, 2005; USEPA, 2006; Obruche et al., 2022).

2.4 Preparation of Samples for GC-MS Analysis Using Solvent Extraction

Liquid-liquid solvent extraction was employed to isolate the organic compounds in the surface and underground water samples. A 10cm3 portion of each water sample was treated with 20cm3 of chloroform and then 20cm3 of diethyl ether in a separatory funnel. The funnel was shaken vigorously until the aqueous and organic layers separated clearly. The organic layer was carefully drained into clean glassware for subsequent GC-MS analysis (Greenberg et al., 1992; Ekpo et al., 2023).

2.5 Microbial Analysis

Sterile distilled water (9 mL each) was placed into four test tubes using a pipette. A sterile 10mL pipette was then used to take 1mL of the thoroughly mixed water sample and it was discarded afterward. A new 10 mL pipette was utilized to mix the sample with the distilled water by drawing it in and out ten times. Exactly 1 mL of this mixture was transferred to the second tube. This process continued until the fourth test tube. A portion (1 mL) of the sample was removed from the last test tube so that each tube contained 9 mL of the solution. A sterile 1ml pipette was used to take 0.1mL of the mixture from the fourth test tube and place it on the surface of Eosine methylene blue agar. The inoculum was evenly spread across the agar surface with a sterile glass rod. The plates were incubated at 37˚C for 24 hours, and the different colonies that appeared were counted and recorded (Nester et al, 2004)

3.0 RESULTS AND DISCUSSION

This section provides the analyzed results of surface and ground water sources near the General Hospital plant in Agbarho, Delta State, which are shown in tables 1 and 2.

Table 1: Results of Organic Contaminants present in Surface and Underground Water

SITE	ORGANIC CONTAMINANTS	RETENTION TIME(mins)
UI	Butylated Hydroxyltoluene	18.51
	Toluene	3.61
	O-Xylene	5.59
U2	Toluene	3.61
	Butylated Hydroxyltoluene	18.53
	P-Xylene	5.60
U3	Butylated Hydroxyltoluene	18.53
	Toluene	3.61

	Ethyl Benzene	5.43
U4	Toluene	3.64
	Ethyl Benzene	5.44
S1	Butylated Hydroxyltoluene	18.53
S2	Toluene	3.61
	Ethyl Benzene	5.43
	O-Xylene	5.61
S3	Butylated Hydroxyltoluene	18.53
S4	P-Xylene	5.63

Table 2. Bacteriological Analysis Results

Site	Coliform Count (Cfu/ml)
S1	25×10^4
S2	28×10^4
S3	11×10^4
S4	10×10^4
U1	2×10^4
U2	7×10^4
U3	31×10^4
U4	4×10^4

3.1 Discussion on Organic Contaminants

The chromatograms displaying the organic contaminants found in surface water and ground water locations are illustrated in Figures 1 – 11. Ethylbenzene was detected at surface water site S2 and ground water sites U3 and U4. Toluene was found in ground water sites U1, U2, U3, and U4, and it was also present at surface water site S2. Xylene was identified in ground water sites U1 and U2, as well as in surface water sites S2 and S4. Butylatedhydroxyltoluene was found in sites U1, U2, U3, S1, and S3. The detection of ethylbenzene, xylene, and butylatedhydroxyltoluene in both surface and ground water aligns with the results reported by Wyasu (2011) regarding the liquid waste treatment facility at the Ahmadu Bello University Teaching Hospital in Zaria, Nigeria.

3.2 Discussion on Microbial Analysis

There was a decrease in the bacterial count from S1 to S4 (25 × 104 – 10 × 104 Cfu/ml), except for S2 (25 × 104 Cfu/ml), where an increase was noted. The lower bacterial counts at sites S1, S2, and S4 may be attributed to the natural selfpurification ability of water. The rise in S2 could be due to the discharge of animal waste from livestock grazing in open fields or those used for farming by the local community near the study area. The colony-forming units in ground water sites U1, U2, and U4 (25 × 104 – 10 × 104 Cfu/ml) were lower than in U3 (31 × 104 Cfu/ml). The hand-dug well (U3) had openings that allowed water and other impurities to enter, which may explain the increase in colony-forming units. The elevated coliform levels observed at the study sites could be due to human and animal feces, as well as other waste from human activities in the bushy areas near the wells. Eventually, these could be washed into the wells by rainwater runoff, leading to contamination.

4.0 CONCLUSION

The current study examined organic pollutants found in both ground and surface water samples from the area. Butylated Hydroxytoluene, Toluene, Xylene, and Ethylbenzene were detected. The results from the microbial analysis show high levels of coliform counts in the surface and ground water locations. This suggests faecal contamination of the water bodies, likely caused by the discharge of hospital wastewater and other pollutants from non-point sources.

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