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Evaluation of environmental and health hazards of hospital waste in Osun metropolis

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Abstract

This study investigates the environmental impact of twenty-four (24) unsecured hospital waste samples collected from Osun State General Hospital dumpsites and surrounding soil. The hospitals, with bed capacities ranging from 400 to 600, are situated within residential areas. Through questionnaires distributed to hospital personnel, we gathered data on the types of waste generated, disposal methods, and the effectiveness of waste management practices. Soil samples from dumpsites, compared with control samples from nearby areas, exhibited significant differences in color and chemical composition. Notably, dumpsite soils were darker, while that of control (adjacent soil) were brown and normal and showed higher levels of biochemical oxygen demand, BOD (40 - 195) mg/dm3, chemical oxygen demand, COD (190 - 400) mg/dm3 , and other parameters such as temperature (25.5 - 28)°C, pH (6.41 - 6.48), dissolved oxygen, DO (2.10 - 5.62) mg/dm3, Pb (1.97 - 4.85) mg/dm3, Mn (0.04 - 0.07) mg/dm3, Co (0.21 - 0.33) mg/dm3, Cr (0.42 - 0.50) mg/dm3 and Ni (0.04 - 0.10) mg/dm3 , all exceeding WHO guidelines. These findings underscore the potential health risks posed by improper waste disposal and emphasize the need for improved hospital waste management to mitigate environmental and health hazards.

Keywords: Hospital Waste; Heavy Metals; Soil Contamination; Environmental Impact; BOD; COD; WHO Guidelines

1. Introduction

Healthcare or medical waste, often referred to as hospital waste, consists of a broad range of materials generated during the processes of diagnosing, treating, and immunizing patients [2]. These materials are inevitable by-products of medical care, and their proper disposal is crucial to minimize potential risks to human health and the environment [14]. Healthcare waste is categorized into several types, each presenting distinct hazards and requiring different management strategies [2].

Infectious waste is perhaps the most commonly recognized form of medical waste [16]. It includes materials that have been contaminated by infectious agents like bacteria, viruses, and fungi, which can cause disease [13]. Examples of infectious waste include used bandages, gloves, syringes, needles, and any materials that have come into contact with bodily fluids or infected patients [3]. If not properly managed, these materials can pose significant risks by spreading infections, especially in healthcare settings [5]. This type of waste is typically sterilized through processes like autoclaving or incineration before disposal to eliminate the pathogens it may contain [2].

Hazardous waste is another significant category and refers to materials that are dangerous due to their chemical, physical, or biological properties. These materials may be toxic, corrosive, flammable, or reactive, and pose risks to both human health and the environment. Examples of hazardous waste include chemicals used in medical laboratories, such

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as solvents and disinfectants, as well as certain medications and medical devices that contain harmful substances like mercury. Due to the risks associated with hazardous waste, special handling and disposal procedures are required, often including secure containment and specialized treatment methods, such as incineration or chemical neutralization [4].

Pathological waste consists of human tissues, organs, body parts, and fluids removed during surgeries or autopsies. This type of waste may contain infectious agents, making it a serious health risk if not properly handled and disposed. Pathological waste is typically incinerated to ensure its safe disposal and prevent contamination [6].

Pharmaceutical waste includes expired, unused, or leftover medications and vaccines. Improper disposal of pharmaceutical waste can lead to environmental contamination, especially if chemicals from medications leak into water systems. Proper disposal involves returning unused drugs to appropriate facilities or incinerating them [17].

Biological waste refers to materials like pathological waste, human tissues, and organs that are generated during medical procedures such as surgeries or autopsies. Pharmaceutical waste includes expired or unused medications and vaccines that can no longer be used for patient care. These types of waste must be handled with great care because they pose significant risks to public health and the environment. Biological waste may harbor infectious agents that could potentially spread diseases, while pharmaceutical waste, if not disposed of properly, could lead to environmental contamination, especially if harmful chemicals leach into water systems [1].

General waste, on the other hand, consists of materials that do not pose a direct health risk to humans or the environment. This category includes everyday items like paper, packing materials, food scraps, and non-hazardous items that are generated during regular hospital operations. While these materials are less dangerous compared to hazardous or infectious waste, they still require appropriate disposal to avoid environmental degradation [8].

Environmental concerns related to hospital waste have reached a critical level, as improper management of these materials has become one of the most pressing challenges in environmental and public health sectors. If medical waste is not properly contained, treated, or disposed of, it can lead to pollution of the soil, water, and air [9]. The contaminants present in hospital waste—such as pathogens, chemicals, and heavy metals—pose a serious risk of environmental damage [11]. Adjacent soil is particularly vulnerable to contamination from hospital waste. Waste materials, including medical and pharmaceutical refuse, can leach harmful substances into the nearby soil. This can lead to soil pollution, which can affect plant growth and agricultural productivity. The contamination of soil can also create a pathway for harmful substances to enter the food chain. Plants grown in contaminated soil may absorb toxic chemicals or pathogens, which can then be consumed by animals or humans, causing long-term health problems [12].

Moreover, improper disposal of medical waste can also have significant effects on water and air quality. For instance, leachates from improperly disposed waste can seep into groundwater, potentially affecting drinking water supplies. Incineration or open burning of medical waste can release harmful gases into the air, contributing to air pollution and respiratory problems [15].

Improper disposal of hospital wastes in dumpsites or landfills expose the surrounding environment and communities to significant dangers. Particularly, medical waste dumped in these locations can become breeding grounds for disease and health hazards, as it may contain infectious materials, harmful chemicals, and even sharp objects that can cause injuries or spread infections [7]. A major concern with dumpsites is the creation of leachate, a toxic liquid produced as waste breaks down over time. This liquid can seep through the layers of waste and eventually reach the water table, contaminating nearby groundwater sources that are used for human consumption. The presence of leachate in the water can make it unsafe for drinking, bathing, or other daily uses, leading to health risks such as waterborne diseases and poisoning from hazardous chemicals [8].

The contamination of water sources due to medical waste disposal in dumpsites can be a significant problem for local inhabitants and the surrounding environment. The harmful effects are not limited to water pollution. Leachate can also affect the soil, making it toxic and unsuitable for plant growth. This can disrupt local agriculture, which relies on healthy soil for crop production. Furthermore, the chemicals and pathogens in the waste may enter the food chain through contaminated water and soil, posing risks to both animal and human life [18].

The presence of hazardous materials in dumpsites can also lead to long-term environmental degradation, impacting local ecosystems. For example, chemicals from medical waste can disrupt the balance of ecosystems, killing off important plant and animal species that depend on the land and water for survival. This could result in reduced biodiversity, affecting not only wildlife but also the local economy, especially for communities reliant on agriculture or fishing [14].

In addition to ecological harm, the presence of medical waste in dumpsites can increase the risk of disease outbreaks. With contaminants such as viruses, bacteria, and toxic chemicals present in the waste, local populations are at a higher risk of exposure through direct contact with the waste or through consumption of contaminated resources. This can lead to public health emergencies and put a significant strain on local healthcare systems [3].

Proper management of hospital waste is crucial to mitigating the environmental and health risks associated with improper disposal. The negative effects of environmental contamination can be significantly reduced through the implementation of adequate waste management practices, which include proper segregation, treatment, and disposal of hospital waste. Failure to properly manage these wastes can result in harmful pollutants that endanger both public health and the environment [17].

A key element of waste management is segregation, which involves sorting waste from the point of production. This means that hospital staff should immediately classify waste into different categories, such as infectious, hazardous, pharmaceutical, and general waste, before disposal. By sorting the waste early, hospitals can ensure that each type of waste is treated and disposed of according to its specific requirements, minimizing the risk of cross-contamination and ensuring that hazardous materials are managed correctly [6].

Once the waste has been segregated, proper disposal methods must be employed. These methods can vary depending on the nature of the waste and may include incineration, autoclaving (steaming), or chemical treatment [4]. For example, infectious waste may be treated through incineration to completely destroy harmful pathogens, while pharmaceutical waste may require chemical treatments to neutralize toxic substances. Autoclaving is another effective treatment for medical waste, especially for materials that are sterilized by steam and pressure to kill bacteria and viruses. These disposal methods help reduce the risk of environmental contamination and ensure that the waste is rendered harmless before being discarded [3].

In addition to proper segregation and treatment, hospitals should also have clear protocols in place for storage and transportation of waste, ensuring that waste containers are clearly labeled, securely sealed, and safely transported to treatment or disposal sites [1]. Waste storage areas should be isolated from public access and equipped with measures to prevent leaks or spills that could harm the environment or individuals working with the waste.

According to Sanitary Rules and Regulations, it is essential to adhere to specific procedures before hospital waste is incinerated, disposed of in designated landfills, or recycled. There are various established rules, regulations, and guidelines designed to ensure the safe management of hospital waste. These guidelines are put in place to reduce the impact that medical waste may have on both the environment and public health [14].

International organizations, such as the World Health Organization (WHO), along with various national and local health bodies, provide comprehensive procedures for the treatment, disposal, and handling of hospital waste [10]. These guidelines aim to minimize the risks associated with hazardous materials and encourage best practices for managing medical waste. The WHO, in particular, outlines safety protocols for segregating, storing, treating, and disposing of medical waste to prevent contamination and health hazards [17].

These established rules and guidelines serve as a foundation for promoting safe hospital waste management, aiming to reduce the adverse effects of waste on both human health and the environment. By following these safety measures, hospitals can help reduce the risk of soil contamination, water pollution, and airborne hazards that could negatively impact surrounding communities.

The study aims to assess the environmental health hazards associated with hospital waste in Osun Metropolis by analyzing the physicochemical properties of soil from dumpsites and nearby areas. This research will provide insights into how improperly managed hospital waste may contribute to soil pollution and potentially affect the health of the surrounding population. By studying the composition and contamination levels in the soil, the study seeks to identify any dangerous chemicals, heavy metals, or pathogens that may have leached into the environment from hospital waste, thereby contributing to long-term health risks.

2. Materials and methods

2.1. Sampling Sites

Six state hospitals in Osun City's three federal constituencies were selected for this study, with bed capacities ranging from 400 to 600. These hospitals are located adjacent to residential areas.

2.2. Administration of Questionnaires

Questionnaires were distributed to hospital personnel to gather information on the types of waste generated, the disposal methods used, and the effectiveness of waste management practices.

2.3. Sample Collection

From January to April 2024, soil samples were collected from unsecured hospital waste dumpsites and adjacent soils 50 meters away in Osun East (Ilesha and Ile-Ife), Osun West (Iwo and Ede), and Osun Central (Ikirun and Osogbo).

Table 1 Types of waste generated by hospitals

SAMPLING SITE	Osun West		Osun East		Osun Central	
WASTE	A	B	C	D	E	F
Blood	+	+	+	+	+	-
Urine	+	+	+	+	+	-
Faeces	+	+	+	+	+	-
Sputum	+	+	+	+	+	-
Semen	+	+	-	+	-	-
Cerebrospinal	-	-	-	+	-	-
Fluid	+	+	+	+	-	-
Ascetic Fluid	-	-	+	+	-	-
Used water	-	-	+	+	+	+
Skin Snip	+	-	+	+	-	-
Expired fluids	-	-	+	+	+	+
Pus	-	+	+	+	-	-
Chemicals	-	-	+	+	-	-
Used Rubber	-	+	+	+	+	+
Gloves	+	+	+	+	+	-
Amputated body	-	-	+	+	-	+
Parts	+	+	+	+	+	-
Syringes	+	+	+	+	+	+
Needles	+	+	+	+	+	+
Specimen	+	+	+	+	+	-
Injection Bottles	+	+	+	+	+	-
Used cotton	+	+	+	+	+	-
Swabs	+	-	+	+	-	-
Used Gauze	+	+	+	+	+	+

Key: +, present; -, Absent; A -F, Hospitals sampled

2.4. Physico-chemical analysis

The assessment of soil characteristics involved various methods. Soil color was visually evaluated, while odor was determined organoleptically using human senses. The soil temperature was measured using a PT-2 digital thermometer (ST-3 model). For pH analysis, a Metro Ohm model (610 ion meter) pH meter was employed. The dissolved oxygen (DO) content was analyzed using the Winkler titration method, and biological oxygen demand (BOD) was determined after a

5-day incubation period at 20°C. The chemical oxygen demand (COD) was assessed by refluxing the sample with potassium dichromate. Heavy metal analysis was conducted using an Atomic Absorption Spectrometer (AAS) to detect metals such as lead (Pb), manganese (Mn), cobalt (Co), chromium (Cr), and nickel (Ni) [18].

2.5. Statistical Analysis

Data were presented as mean **+/-** standard deviation (SD) of three independent experiments. One- The data were analyzed using one-way analysis of variance (ANOVA).

3. Results

Figure 1 displays the study area's location maps. Hospital waste dump locations in Osun Central, East, and West are depicted in Figures 2, 3, and 4, respectively. As seen in Figure 1a, the country is administratively divided into 36 states, including Osun State, and a Federal Capital Territory (FCT), Abuja. As seen in Figure lb, the state is separated into 30 Local Government Areas (LGAs). Since the country's land use order gives the state governor control of the land in each state, it may have been the perfect arrangement for solid waste management overall: LGAs to collect and transport the garbage, and the state government to provide disposal facilities.

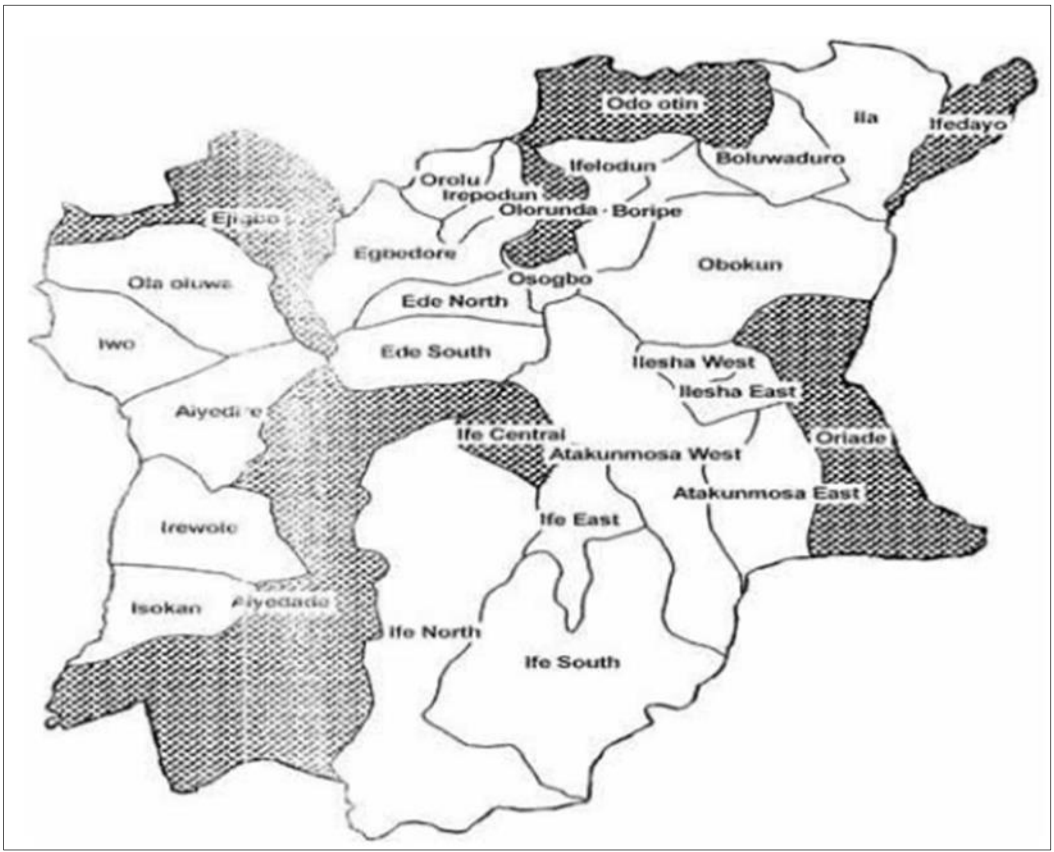

Figure 1 Location map of the study area

Figure 2 Hospital waste dumpsite in Osun state (Osun central)

Figure 3 Hospital waste dumpsite in Osun state (Osun East)

Figure 4 Hospital waste dumpsite in Osun State (Osun West)

Table 2 Mean value of physico-chemical parameters obtained from hospital dumpsites

	Ikirun	Osogbo	Iwo	Ede	Ilesa	Ile-Ife	
Parameter	**R m S.D**	**R m S.D**	**R m S.D**	**R m S.D**	**R m S.D**	**R m S.D**	**WHO permit level (2022)**
Odour	Foul	foul	Foul	foul	Foul	Foul	
Colour	Black	black	Black	black	Black	Black	
Temperature°C	28-29, 6.18, ± 0.01	27-29, 6. 47, ± 0.00	26-28, 27, ±0.01	25-26,25.50, ± 0.01	26-28,27,± 0.01	25-27,26, ±0.01	15
P^H	6.18-6.80, 6.48 ±0.00	6.01-6.71, 6.47, ± 0.00	6.12-6.70, 6.41, ± 0.00	6.17-6.80, 6.48, ±0.00	6.18-6.79, 6.48, ±0.00	6.12-6.72, 6.42 ±0.00	6.5 - 8.5
DO (mg/L)	2.10-4.00, 3.40,+0.01	2.90-4.00, 3.55, ±0.01	5.20-6.00, 5.62,± 0.00	4.88-5.20, 5.04, ±0.01	4.69-6.00,5.34, ±0.01	3.59-4.68, 4.14, ±0.01	9.2
BOD (mg/L)	20-200, 110, ± 0.88	120-300, 195, ±0.86	20-60,40, ± 0.16	30-50,40, ±0.16	40-160,100, ±0.78	80-120,100,±0.78	100
COD (mg/L)	140-420, 315, ± 1.24	100-610, 362.50, ± 2.08	120-320,190, ±0.89	160-520, 340, ±2.01	180-620,400, ±2.09	120-640,380,+2.09	200
Pb (mg/L)	1.08-9.45, 4.70, ± 0.03	0.36-4.79, 1.97, ± 0.02	2.02-5.87, 4.24, ±0.02	3.02-4.87, 3.95, ± 0.01	2.08-6.49, 4.29, ±0.02	1.09-8.55, 4.85, ±0.02	5
Cd (mg/L)	-	-	-	-	-	-	
Mn (mg/L)	0.05-0.08, 0.07, ±0.00	0.05-0.06, 0.16, ±0.00	0.01-0.90, 0.05, ±0.00	0.05-0.08, 0.07, ±0.00	0.01-0.06, 0.04,+0.00	0.01-0.07, 0.04, ±0.00	1
Co (mg/L)	0.09-0.67, 0.33, ±0.00	0.00-0.65, 0.21, ±0.00	0.00-0.61, 0.24, ± 0.00	0.08-0.66, 0.33, ±0.00	0.00-0.65, 0.04, ±0.00	0.00-0.66, 0.33, +0.00	
Cr(mg/L)	0.30-0.60, 0.47, ± 0.00	0.12-0.88, 0.42, ± 0.00	0.25-0.81, 0.48, ± 0.00	0.31-0.59, 0.45, ± 0.00	0.26-0.79, 0.50, ±0.00	0.30-0.59, 0.45, ± 10.00	
Ni (mg/L)	0.00 - 0.09,0.04, ± 0.00	0.00-0.17, 0.05,±0.00	0.00-0.19, 0.08, ± 0.00	0.000.18,0.09 , ± 0.00	0.00-0.20, 0.10, ±0.00	0.00-0.19, 0.10, ±0.00	

(-) = below detection level; Values are means of triplicate readings; R= Range, M =Mean, SD =Standard Deviation., Adjacent Soil (Test Soil)

Table 3 Mean values of physico-chemical parameters obtained from hospital adjacent soil

	Ikirun	Osogbo	Iwo	Ede	Ilesa	Ile-Ife	
Parameter	**R m S.D**	**R m S.D**	**R m S.D**	**R m S.D**	**R m S.D**	**R m S.D**	**WHO permit level (2022)**
Odour	Normal	Normal	Normal	Normal	Normal	Normal	
Colour	Brown	Brown	Brown	Brown	Brown	Brown	1
Temperature°C	27-29, 28, ± 0.01	25-27, 26, ± 0.01	24-26, 25, ± 0.01	26-28, 26.50, ± 0.01	27-29,28, ±0.01	30-32, 31, ± 0.01	15

PH	4.20-4.80, 450, + 0.00	4.30-4.90, 4.60 + 0.00	4.12-4.70, 4.41, +0.00	4.41-4.80, 461, + 0.00	4.18-4.79, 4.49 +0.00	4.12-4.72, 4.42, +0.00	6.5 – 8.5
DO (mg/L)	2.80-4.20, 3.50, +0.01	3.50-4.70, 4,10, +0.01	6.10-6.80, 6.45, +0.00	3.60-4.80, 4.20, +0.01	6.50-8.00,7.25, +0.01	5.40-7.70, 6.55, +0.01	9.2
BOD (mg/L)	40-260,150, + 0.88	140-360, 250, + 0.86	40-80, 60, + 0.16	50-90, 70, + 0.16	60-140,100, +0.78	100-140,120, + 0.80	100
COD (mg/L)	180-420,300, + 1.24	120-680, 400, + 2.08	140-340, 240, + 0.89	180-540, 360, + 2.01	180-680,430, + 2.09	140-680,410, + 2.07	200
Pb (mg/L)	1.60-8.40,4.73, + 0.03	0.48-5.80, 3.40, +0.02	2.04-6.00, 4.02, +0.02	2.08-5.80, 3.94, +0.01	2.06-6.80, 4.43, +0.02	1.04-8.50, 4.77, +0.02	5
Cd (mg/L)	———	———		———	———	———	——
Mn (mg/L)	0.04-0.07, 0.06, +0.00	0.06-0.8, 0.07, + 0.00	0.02-0.08, 0.05, +0.00	00.060-09,0.08,+0.00	0.02-0.07, 0.05, +0.00	0.03-0.08, 0.06, +0.00	1
Co (mg/L)	0.07-0.07, 0.39,+ 0.00	0.01-0.68, 0.35, +0.00	0.01-0.72, 0.37, +0.00	0.70-0.70, 0.40, +0.00	0.01-0.70,0.36, +0.00	0.02-0.80, 0.41, +0.00	
Cr(mg/L)	0.28-0.64, 0.46,+ 0.00	9.16-0.82, 0.49 + 0.00	0.30-0..80, 0.55,+0.00	0.42-0.60, 0.51, +0.00	0.28-0.80, 0.54, +0.00	0.40-0.60, 0.50 + 0.00	
Ni (mg/L)	0.01-0.08, 0.05,+ 0.00	0.01-0.18, 0.10, +0.00	0.00-0.20, 0.10, +0.00	0.00-0.16, 0.08, +0.00	0.00-0.18, 0.09, +0.00	0.00-0.20, 0.01, +0.00	

Values are means of triplicate readings; R= Range, M =Mean, SD =Standard Deviation.

4. Discussion

Table 1 summarizes the most popular means of disposing trash in hospitals such as incineration, municipal and waste disposal, with the exception of flushing, which is not an open disposal option. Biochemical waste can be disposed of through incineration [19]. Open burning is often carried out without the use of any kind of incinerator. In contrast, untreated wastes were left in the open dump sites in the hospital sample, burning once or twice a week. Between the time when waste is dumped and burned, microorganisms that are present in the untreated waste may be released into the environment. Even while there isn't a substantial health danger to the environment from the municipal disposal of untreated biochemical waste, workers at such sites and scavengers may be at risk. In the event that these waste disposal companies simply dump the biochemical waste in an open manner somewhere else, there will be health risks in the new surroundings. Biochemical waste should be disposed of by land in sanitary landfills with personnel assigned to oversee operations, arrange deposits, cover trash every day, and isolate waste from the environment geologically [2]. Infections may arise from the discharge of hospital liquid waste into septic tanks near an underground water supply that are uphill. These tanks may harbor harmful germs.

According to [7], insufficient technology is to blame for inappropriate medical waste disposal since the majority of hospitals lack contemporary equipment capable of managing hospital wastes. Finances: With hospitals facing more demands and fewer resources, there is not enough money to provide disinfectants, autoclaves, incinerators, and other necessities. Culture: Because patients and other healthcare consumers come from a community with poor general sanitation, even when facilities are present, they are not used to their full potential rules: There aren't many health facilities with explicit waste management rules. Policies regarding the discharge and disposal of hospital waste are scarce or nonexistent at the national level, and when they are, they are rarely implemented.

Tables 2 and 3 provide, respectively, the mean values of the parameters collected in Osun Central, East, and West state hospitals in Osun State from January to April, 2024.

The test soil had an unpleasant and dark color and smell, whereas the neighboring soil had a typical and brown color.

In contrast to the 15°C World Health Organization (WHO) allowed limit, the temperature fluctuated between 28°C and 29°C and remained relatively consistent during the duration [17]. These could result from the kind of garbage (hazardous) that was dumped on the soil as well as the afternoon sampling. The physical, chemical, and biological processes in the soil are typically impacted by this temperature. The pH values of the dumpsite soil were consistently low, ranging from 4.20 to 4.83, across all the samples that were analyzed, which could be explained by the ash that was produced during the open burning of the waste. According to [8], these ashes, or lime, can find their way into the soil and neutralize its acidic composition. All aquatic life, including the creatures that carry out the soil's natural cleansing process, depends on oxygen. The soil adjacent to the hospital and the soil from the dumpsite both had higher concentrations of dissolved oxygen (2.10–5.20mg/L) at sampling points 1 and 2. This could be because of increased waste disposal or other human activities that promote the growth and proliferation of these organisms, which in turn consumes available oxygen.

The amount of organic matter pollution, the decomposition of organic materials, and the soil's ability to purify itself are all gauged by the dissolved oxygen (DO). The mean values of DO (2.10 - 7.70mg/L) for the soil close to the hospital and the soil from the dumpsite were higher than the 9.2 mg/L WHO threshold. Dissolved oxygen (DO) concentrations were from 6.50 to 8.00mg/L in the Osun east samples for adjacent soil and dumpsite soil, and from 5.20 to 6.00mg/L in the Osun west samples. The pattern seen in the Osun Central samples was most likely brought about by the ongoing receipt of garbage and the delays in its evacuation. In comparison to the 2022 WHO standard limits of 100 mg/L for BOD and 200 mg/L for COD, the mean values obtained for BOD (110 - 195) mg/L and COD (315 - 362.50) mg/L at Osun Central State hospitals for both sample stations were the highest while that of Osun west (40 mg/L) was the lowest. Furthermore, heavy metals have detrimental consequences on the ecosystem and human health. They lead to long-term problems with the respiratory system, gastrointestinal tract, brain system, cardiovascular system, skin and lung cancer, kidney damage, and blood-forming organisms. Some heavy metals were found to be greater in all the soil, but they were especially high in Osun Central (Ikirun and Osogbo). Pb is a well-known toxin that is persistent in the environment and does not break down. For those who farm near the hospital and for the general population who eats vegetables in the city, this is therefore a serious worry.

Due to their toxic, genetoxic, and carcinogenic properties, hospital solid waste has been shown to constitute a major concern to environmental health. It may also have an adverse influence on the biological balance of the surrounding environment [17].

5. Conclusion

This study underscores the pressing need for improved hospital waste management practices in the Osun Metropolis. The findings reveal that current waste disposal methods significantly harm the environment and pose serious health risks to nearby populations, particularly in residential areas surrounding the hospitals. Elevated levels of biochemical oxygen demand (BOD), chemical oxygen demand (COD), heavy metals, and other parameters in dumpsite soils, compared to control samples, highlight the detrimental impact of unsecured waste disposal. To mitigate these risks, compliance with WHO guidelines and the establishment of proper waste treatment facilities are essential. Implementing stricter waste management policies will play a crucial role in minimizing environmental degradation and safeguarding public health

Compliance with ethical standards

Disclosure of conflict of interest

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Author contribution

- **Ishola, Abdul Dimeji:** Investigation, Data curation, Investigation, Resources.
- **Fagbemi Josephine Omolara:** Investigation & review
- **Adeoye, Sunday:** Data curation, investigation
- **Lawal, Rasheed Tunde:** Writing – review & editing

- Oyebanji, Ibraheem Olajide: Investigation, writing – review & editing.
- **Ishola, Lateef Taiwo:** Writing – review & editing

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