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Detection of Microbiological Activity in Some Collected Water Samples near Dumping Site of Solid Waste, Khartoum North, Sudan

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ABSTRACT: A study was conducted at the Wadafiea landfill in Al Khartoum Bahri (North), Sudan, to determine the level of microbial contamination in water samples collected from nearby areas around the landfill. The purpose of this study was to evaluate the impact of solid waste disposal in open dumps and assess the associated risks to water. The study tested for coliform bacteria (*E.coli*) and compared the seasonal differences between the samples collected during the dry and rainy seasons. The results indicated higher levels of *E.coli* contamination in each season, with the rainy season samples showing particularly high levels (66.03×10^4 cfu/ml) compared to the dry season (31.93×10^4 cfu/ml). It was concluded that the groundwater was highly polluted due to the current landfill location. The local authorities and the department of solid waste management were advised to close this landfill and relocate it to the outskirts of Al Khartoum Bahri (North) city. Additionally, it was recommended that international regulations for standard landfills should be maintained and implemented.

KEYWORDS: Wadafiea dumpsite; Khartoum North Sudan; microbiological; groundwater; municipal waste; *Escherichia coli*; coliform

1. Introduction

Waste is a variety of materials that varies from one country to another and even within regions, depending on the local way of life. In general, waste is what remains after any human activity, including daily life, as well as various sectors such as industry and agriculture. This waste has no primary or secondary use at the source, although it may become valuable if it is located in a different place where conditions are more suitable for its use. The international population boom and associated hyper-commercial activities have generated massive amounts of household, municipal, and commercial waste [1]. However, the increasing amount of waste is not being effectively treated, especially in developing countries. As a result, waste disposal times are enormous, and poorly controlled waste poses a serious threat to the ocean and to major cities around the world, particularly in Africa [2]. In Khartoum, the problem of solid waste management is exacerbated by the fact that waste has been disposed of randomly, making it one of the most important environmental pollutants. Waste disposal is done through traditional methods such as open burning and pits, leading to numerous environmental problems. Several factors contribute to the growth in the quantity of waste in Khartoum. Environmental and health control have become essential aspects of people's lives and social activities, according to research conducted in some Sudanese cities. Solid waste management can reduce or eliminate negative impacts on the environment and human health, support economic development, and improve the quality of life [3]. When waste is dumped on the ground, microorganisms such as bacteria and fungi use the waste components as a source of nutrients for their growth and break down the organic matter in the waste for reproduction [4]. Landfills provide a rich source of microorganisms, most of which are pathogenic. Atmospheric transport is a key mode of microbial transmission, and airborne transmission of plant and animal pathogens can have major impacts on ecosystems, human health, and agricultural productivity [5].

In Khartoum State, there is no effective system comparable to waste management systems in cities around the world. All this has led to a deterioration of the ecological situation of Al Khartoum Bahri, and most of the yards have been converted into garbage dumps (*kusha*), possibly due to increasing population, industrialization, and urbanization. Efforts have been made to effectively manage solid waste because of perceived negative health and environmental impacts [6]. The overall objective of municipal solid waste management is the collection, sorting, treatment, and disposal of solid waste generated by all groups of urban communities in a sustainable, environmentally and socially satisfactory manner using the most economically available resources. Waste should serve as primary and secondary raw materials for the production of consumer goods in cities. For example, in Al Khartoum Bahri (North) city, during the conflict years in certain areas in Sudan, the urban areas in Al Khartoum (Bahri) North city grew as a result of the migration of the population from unsafe rural areas to safer areas. The city is now facing major problems due to the influx of rural population into the city. These problems include waste disposal through improper methods, collection, recycling, and treatment in landfills, which can pose health risks to the residential and urban population. The current situation is alarming, especially in Al Khartoum Bahri city (North), and is exacerbated by the lack of awareness among the population and communities, the lack of facilities and planned landfills to control waste disposal, and the lack of an effective role of the local government in controlling ecosystems. Uncollected waste is dumped in Al Khartoum Bahri (North), along roads, and in sewers, contributing to the proliferation of insects and the spread of diseases. Most waste in Khartoum North (Bhari) is indiscriminately dumped in open dumps, dumped on empty lots, or burned through the means of local residents, and all of these conventional methods of waste disposal result in air, soil, and water pollution. Thus, this study focused on the following objectives: to evaluate the impact of municipal waste disposal in open dumps and, to assess the contamination with coliform bacteria in water samples around the landfill and to compare the dry and rainy seasons of microbiological activities in the water samples around the landfill.

2. Materials and Methods

2.1. Study area.

This study was conducted in the residential communities around Wadafia landfill which located at Al Khartoum Bahri (North), Khartoum state, Sudan during the period of (October 2019 to August 2020).

2.2. Laboratory analysis.

Twenty water samples were collected from areas adjacent to the Wadafiea landfill in sterile (350 ml) plastic containers for microbiological analysis. Ten samples were collected during the dry season and ten during the rainy season, with six samples taken from East well (A), East well (B), Southern East well, South well (A), South well (B), and West well B. Additionally, three samples were taken from a farm well (North A), well (North B), and well (West A), and one sample was collected from a water canal used for irrigation next to the landfill on the north side. All water samples were adjacent to the landfill. A specialized technician from the Faculty of Sciences and Technology - Al Neelain University collected the samples and immediately transported them to the laboratory of the Research Institute of Environment and Natural Resources and Desertification in Khartoum State, Sudan, for microbiological analysis. Microbiological examination was started promptly within two hours to avoid unpredictable changes.

To determine the total *E.coli* bacteria in the water samples, microbial densities were enumerated, and discrete bacterial colonies were isolated. Three different types of media were used for the growth, isolation, and detection of Enterobacteriaceae: Blood agar medium for culturing bacterial cells, Mac-Conkey agar for isolating and detecting Enterobacteriaceae, and Eosin methylene blue (EMB) agar medium for isolating and differentiating *E.coli* from other bacteria. The spread technique method was used. Each water sample was prepared as a six-fold serial dilution in clean water up to a concentration of 10^6, and 0.1 milliliters of each dilution was plated on desiccated nutrient agar plates in triplicate. All incubations were conducted aerobically for 24 hours at 35 °C, and dishes containing 30 to 300 colonies were selected and counted. Bacterial growths were measured by a colony counting machine, and the total colonies were calculated by multiplying the number of colonies by the dilution ratio (colony forming units per milliliter (cfu /ml) [7].

3. Results and Discussion

The findings of the microbiological analysis of the water samples that were examined during the dry and rainy seasons close to the Wadafiea dumpsite of solid waste are shown in Table 1. In the dry season, all water samples were microbiologically analyzed and found to contain coliform bacteria (*E. coli*). The total numbers of *E. coli* colonies ranged from (32.3 x10^4 cfu/ml) in well (B) on the southern side to (73.3 x10^4 cfu/ml) in well (A) on the northern side with the exception of the canal, well (B) at the western and eastern sides, and well at the southeastern side, which showed (negative) results.

Table 1. Results of microbiological of water samples near dump site of solid waste at dry and rainy season

Parameter	Channel	Well /North (A)	Well /North (B)	Well /West (A)	Well/west (B)	Well/East (A)	Well/ East (B)	Well/ Southern East	Well/ South (A)	Well/ South (B)	Cont. (1) well	Cont. (2) channel	[a]Maximum Value	[b]Canadian Value	[c]WHO Value
E. Coli (cfu/ml) Dry Season	0	73.3x10^4	40.3 x10^4	66.3x10^4	0	68.3 x10^4	0	0	38.67 x10^4	32.3 x10^4	0	0	Shall not be detectable in any 100 ml sample	None in any 100 ml of sample	Must not be detectable in any 100ml sample
E. coli (cfu/ml) Rainy Season	115.3 x10^4	99 x10^4	72.7 x10^4	0	90.67x10^4	53 x10^4	0	63.3 x10^4	89.67 x10^4	76.67 x10^4	0	0	Shall not be detectable in any 100 ml sample	None in any 100 ml of sample	Must not be detectable in any 100ml sample

[a]Sudanese Maximum Value by SSMO, 2016; [b]Canadian Guideline Value, 2019; [c]WHO Guideline Value, 2018

While in the rainy season, all water samples recorded positive findings with *E.coli* numbers ranging from (53 x10^4 cfu/ml) in well (A) at the Eastern side to (115.3x10^4 cfu/ml) in the canal, with an uncountable number of colonies in serial dilutions from (10^1 to10^3) for both seasons, except for well (A) on the Western side and well (B) on the Eastern side, which turned out to be negative. This may be due to the treatment carried out on the well by adding some antiseptic disinfection. The variation between total numbers of *E. coli* (cfu/ml) in the dry and rainy season results is shown in Table 2. These results indicate that the water samples in the two seasons were contaminated with *E. coli*, but in the rainy season, the pollution was higher (66.03 x10^4 cfu/ml) than in the dry season (31.93 x10^4 cfu/ml). It was discovered that the wells and channel surrounding the Wadafiea dumpsite were unsafe and unstable for human activity when compared with the controlled (1) and controlled (2) and with the Sudanese, Canadian, and WHO standard guidelines for drinking water. The difference between total numbers of *E. coli* (cfu/ml) between sites (Channel, North A, North B, West A, West B, East A, East B, Southern East, South A, and South B) obtained in Table 3 for water samples from different locations illustrates that the average values of total numbers of *Escherichia coli* (cfu/ml) with respect to the Sudanese [8], Canadian [9], and WHO [10] criteria were significantly different ($P < 0.05$) in seasons and locations. According to the results of all water samples, *E. coli* appeared in all water near the landfill site. From this study, it could be concluded that a higher total bacterial count was found in the water samples around the Wadafiea landfill and there was a large variation. This may be due to the fact that the Wadafiea landfill was uncontrolled and managed by the Department of Solid Waste in Al Khartoum Bahri (North). Also, this may be due to the open landfill that receives fresh waste daily and in large quantities, and runoff transferring the sediment, feces, and other pollutants from different areas nearby the Wadafiea landfills or from the Wadafiea landfill, which is located at a higher level than others allowing the movement, migration, and transfer of leachates and liquid materials from the landfill to other areas easily and find their way to the wells.

These results are consistent with previous studies such as [11], which reported a higher number of bacteria and fungi during the wet season compared to the dry season. Additionally, a previous study [12] confirmed that a higher number of coliforms in well water samples is an indication of poor health conditions in the environment resulting from inadequate and unsanitary treatment of solid waste in the area, which leads to the production of a high percentage of microbial organisms. According to [8-10], coliform bacteria such as *E. coli* cannot be present in any (100 ml) specimens of pure water used for domestic activities, and the presence of coliforms in water should be considered unacceptable for human consumption because they are indicators of water impurity. These findings are consistent with the guidelines of Sudanese, Canadian, and WHO norms.

High contamination with pathogenic bacteria, such as *E. coli*, in wells is an indication of fecal contamination and poor water quality, which can be due to several factors, including poor disposal of sewage and solid waste from household activities, sewage and waste discharge from septic tanks and toilets near wells, unsuitable well locations (such as those adjacent to the Wadafiea landfill), and extraction of groundwater from the surface and shallow layers. These findings are in line with a study conducted by [13] at the University of Port Harcourt, Nigeria, which showed a relationship between higher bacterial loads in well water supplies and discharges from septic tanks and waste materials from adjacent landfills. These results are also consistent with the findings of [14], which reported a high concentration of coliform bacteria in well water samples closer to dumpsites.

Table 2. The variation of total number of *E. coli* (cfu/ml) in dry and rainy season.

Season	Mean value	Standard Deviation
Dry season	31.93×10^4	29.614×10^4
Rainy season	66.03×10^4	38.040×10^4

Table 3. The variation of total numbers of *E. coli* (cfu/ml) between locations.

Location	Mean value	Standard Deviation
Channel - North^d	57.67×10^4	63.32982×10^4
North A ^{a}	86.17×10^4	14.49713×10^4
North B ^{e}	56.50×10^4	18.82286×10^4
West A ^{i}	33.17×10^4	36.47693×10^4
West B ^{g}	45.33×10^4	49.72592×10^4
East A^c	60.67×10^4	9.04802×10^4
East B ^{j}	0	0
Southern East^h	31.67×10^4	34.94376×10^4
South A ^{b}	64.17×10^4	28.37193×10^4
South B^f	54.50×10^4	25.14558×10^4

Means in a column with superscripts letters are significantly different ($P < 0.05$)

4. Conclusions

This study showed that the purity of water samples was affected by environmental conditions. Each water sample from the tested wells in the vicinity area contained fecal and coliform bacteria, and their concentrations were found to be higher than the maximum limits recommended by the Sudanese and Canadian WHO guidelines. The isolation of these bacteria from the tested water samples indicates that open dump systems should be replaced with hygienic, high-quality dumps in most urban areas of Al Khartoum Bahri (North). This will help to reduce the distribution of coliform bacteria in the environment and the residential communities around the landfill. Given all these negative impacts of the Wadafiea open landfill, the local government and the solid waste department in Al Khartoum Bahri (North) are recommended to implement a proper and efficient waste management system to reduce further environmental risks that may result from the use of open and unmanaged dumpsites.

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Competing Interest

The authors declare that there are not any conflicts of interest.

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