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Assessment of Retention Ponds and Its Impacts on Health of Residents in Mogadishu, Somalia: Mixed Methods

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Abstract

The purpose of this study was to evaluate the effects of retention ponds on the environment and population health by analyzing water samples from various ponds in Mogadishu, to determine the prevalence of waterborne illnesses that occur during the rainy season in Mogadishu, and to find out what experts thought about the effects of retention ponds on the environment as well as population health in Mogadishu. **Methods:** Mixed designs were used in the study. The first design is an exploratory study where samples are taken from different retention ponds in Mogadishu. The second design involves gathering secondary data from the online FSNAU Dashboard regarding the incidence of rainfall and waterborne illnesses including malaria and cholera. Additionally, a cross-sectional survey of expert opinions using questionnaires was the third design. The 10 water samples were taken from retention ponds in Mogadishu as part of the sample size. Data on the fourth month was also gathered using the FNSAU dashboard, and seventy sample sizes were used for the expert self-administered questionnaire for the third design. Excel was used for data analysis in the initial design. While BMI SPSS versions 22 were used to analyze the data from the Self-administered Questionnaire, additional methods were utilized to compute descriptive statistics, such as mean and standard deviation, and to analyze demographic data in a frequency table. **Findings:** The results show that three samples had unsatisfactory scores (Grade D): Yaqshid (Warshadda Bastada) had a WQI of 80.85, Boondheer (Bondher Pond) had a WQI of 80.64, and Wartanabad (Xamar Jadiid Pond) had a WQI of 80.89. The remaining samples were all rated as fair (grade), which indicates that they ranged from 50 to 75. The months with the largest rainfall already occurred in December, November, and October, when the prevalence of diseases during the rainy season was highest for cholera cases. Although October and December saw a significant number of malaria cases, November did not.

Retention ponds' overall effects on residential environments were evaluated, and the results showed that the standard deviation was 0.802 and the cumulative average mean scores were 4.41 overall. This indicates that the respondents were in agreement that retention ponds in Mogadishu, Somalia, had an effect on residential areas. **Recommendation:** The study suggested that in order to identify retention pond contamination and create treatment units for its management, the Ministry of Health forms a district-level public health committee. All districts must have a sewer system installed by the local government, and retention ponds must be made easier in order to move waste outside of the city.

Keywords

Retention, Ponds, Contamination, Water Quality Index, Waterborne Diseases, Mogadishu, Somalia

1. Introduction

Mogadishu is one of the fastest urbanizing cities globally, mainly driven by improved security and economic prospects. It has a basic network of primary and secondary roads that stretch through the city and connect with the entire region, [1]. But, during the rainy season, flash flood inundates the city roads and disrupts transportation. The causes of the road flooding are primarily due to garbage clogged drainage and partly due to damaged drain structures. The clogged drainage can be Desludging by private sector or Local municipal of Benadir regions, some private sectors did not make informal dumping and while only local government have try to make sludge disposal site located in Karaan district, Mogadishu [2]. But in general, the sewers collect those, pouring in sea and ponds already built.

In addition, floods usually cut off roads and connections to the section of the capital city from other sections. Also this floods collected to roads have other health impacts to the residential population, so that no data is available related to the wastewater management or wastewater treatment facilities/infrastructure, but the only available methods are traditional collection of flash floods and rainwater to the retention ponds built to the each districts.

The objectives of this study were to assess impacts of retention ponds on health of population and environment. The first specific objective was to examination of water samples of different ponds in Mogadishu. The second specific objective was to identify the prevalence of waterborne diseases occurring raining season in Mogadishu, and the third specific objective was to investigate the Experts view's impacts of retention ponds on health and environments in Mogadishu.

2. Literature

The dangers of sewer systems being closed due to health and environmental

concerns are numerous and can have serious consequences. Here are some of the potential risks: First when sewer systems are closed and overflow of retention pond, the wastewater can back up into homes and businesses, causing significant damage to property and posing health risks to occupants [3] [4]. Every Raining seasons the population living in Mogadishu have had such problem blocked sewer system. Some new districts have not sewers at all, such district, located the corner of Mogadishu. As mentioned the world-bank, most urban secondary and tertiary roads in big cities including Mogadishu, Hargeisa, and Garowe, are engineered earth roads without adequate drainage [5].

Second most dangers is Standing water in closed sewer systems in Roads and Retention Ponds in Residential areas can provide a breeding ground for mosquitoes, which can increase the risk of mosquito-borne diseases such as Malaria, chikungunya, filarial, Lymphatic filariasis [6] [7] [8].

Thus, it is anticipated that the existing major health problem of malaria in East Africa would get worse due to climate change [9]. Increased rainfall will attract vectors and increase survival rates, while a 1˚C to 3˚C increase in global average seasonal temperature will allow mosquitoes to spread [10].

In 2021, the Somalia confirmed 8101 malaria cases and 2 related deaths, which was a remarkable reduction compared to 31,021, 22,665 and 27,333, in 2018, 2019 and 2020, respectively, owing to the impact of the malaria control programme collaborated by Somalia Government and WHO [11]. In 2023, the confirmed cases of malaria reported WHO, was a total of 52,804 cases of suspected malaria have been reported of which 1890 (3.5%) have been confirmed positive by Rapid Diagnostic Test (RDT) and blood smear for first two months of the year 2023 [11].

Sewer backups and overflow of retention ponds can cause unpleasant odors and affect air quality, which can be a nuisance to residents and can also exacerbate respiratory issues such as asthma. In Mogadishu has no specific data on air pollution are not available. However, widespread use of coal for cooking is affecting the air quality in the city [9] [12].

Sewer backups and overflow of retention ponds can increase the risk of disease transmission, as they can release bacteria, viruses, and other pathogens into the environment. Heavy rains in 2018, 2020, and 2023 caused flash flooding in the Mogadishu. As known the Somali cities often have very limited infrastructure development. For example, Mogadishu has poor water drainage systems, although some systems built before 1991. Poor drainage causes flooding and regularly pollutes open sewer water supplies, leading to disease outbreaks especially during the rainy season [9].

The common diseases occurring in Mogadishu, were include diarrhea diseases and skin diseases, so that Somalia has had uninterrupted cholera transmission in 29 drought-affected districts since 2022 and in Benadir region since the drought of 2017. Since epidemiological week 1 of 2023, a total of 14626 suspected cases of cholera including 39 associated deaths (CFR 0.3%) were reported from 29 districts of Somalia [11].

3. Methodology

3.1. Study Design

The study used mixed designs. The first is an exploratory study in which samples are collected from various retention ponds in Mogadishu and tested in a laboratory to determine environmental water parameters such as temperature, pH, TDS, and EC. In addition, physical properties of the samples are examined. The second design involved collecting secondary data on the occurrence of Rainfall and waterborne infections such as Cholera and Malaria in online FSNAU Dashboard. The third design was a cross-sectional survey of expert opinions conducted using questionnaires.

3.2. Sample Collection

First, researchers collected 10 water samples from retention ponds in Mogadishu. The samples were tested using water measuring tools, and environmental parameters such as PH, TDS, EC, and temperature were measured in each water sample collected in ponds during the sampling activities. Then, using a Samsung Galaxy A20, photographs were taken to determine the physical appearance of the samples.

The second method involves collecting data from FAO FSNAU Dashboard websites and selecting indicators such as climate/rainfall difficulties, Cholera instances, and Malaria cases from August to December 2023, with a special focus on the Deyr Raining Season in Somalia.

The third group employed questionnaires prepared for self-administration and asked academic students, lecturers, senior lecturers, and assistant professors at the University of Somalia (UNISO). So the sample size was seventy (70) individuals. The purpose sample was employed to aid the easy selection of field specialists.

3.3. Data Collection

Data were obtained using three methods. The first method is primary data collection of water samples from the retention pond. Measure or estimate the pollution level in the retention pond (Table 1). The second methods secondary data collection was to collect data on waterborne diseases in online databases hosted by the FSNAU Dashboard. The third data was also primary data collection method by using questionnaire that enquired experts working or studying at the University of Somalia (UNISO).

3.4. Data Analysis

The Water Quality Index (Table 2), or WQI, is generated by weighting each measure, then normalising and standardising the weights and characteristics, and then aggregating the WQI score to give acceptance or rejection of water quality on this scale. The four essential factors used in this experiment were total dissolved solids (TDS), pH, electrical conductivity, and temperature. The standard

Table 1. District and names of ponds.

NO	Districts	Ponds	Samples
1	Howlwadaag	Hareed Pond	1
2	Hodon	Sigaale Pond	1
3	Howlwadaag	Hayaan Pond	1
4	Wadajir	Buulahubey Pond	1
5	Wartanabad	Herta Shiekh Ali Pond	1
6	Wartanabada	XamarJadidi Pond	1
7	Waaber	KM 4 Ponds	1
8	Boondheer	Boondheer Pond	1
9	Wartanabad	15 May Ponds	1
10	Yaqshid	Warshadda Bastada Pond	1

Table 2. Water quality index (WQI); By Mishra *et al.* (2009) [13].

NO	WQI RANGE	QUALITY SCORE	GRADES
1.	0 - 25	Excellent	A
2.	25 - 50	Good	B
3.	50 - 75	Fair	C
4.	75 - 100	Poor	D
5.	100 - 150	Very bad	E
6.	Above 150	Unfit For Drinking	F

normal units of pH were 8.5, TDS was 500 mg/l, electric conductivity was 300 S/cm, and temperature was 25 degrees Celsius.

The data was analyzed using an Excel spreadsheet, and the rectification mistakes were checked using an online system on water-research.net, as well as conventional methodologies from Mishra *et al.* (2009) [13] and Mr. Brian Oram, PG (2018) [14].

While data from the Self-administered Questionnaire were analyzed using BMI SPSS versions 22, demographic data were analyzed in a frequency table, and others were used to calculate descriptive statistics, specifically mean and standard deviation, as well as the cumulative average of mean and standard deviation for each table.

4. Result

The result parts are divided into three sections. The first component is an experiment in water analysis that examines physical characteristics such as TDS, EC, PH, and pond water temperatures collected from 10 different ponds in Mogadishu, Somalia. The second section portion consists of a questionnaire collected from specialists to examine how retention ponds can affect the health of the community as a whole. The Third sections covered the prevalence of water-related

diseases in secondary data.

4.1. Physical Testing of Water in Retention Ponds

In Table 3, presented the four physical parameter such as TDS, EC, PH and Temperature, so that Boondheer (Bondher Pond) had highest TDS, and EC (3021 ppm, & 5986 u/ms), while Yaqshid (Warshadda Bastada) had second majority TDS and EC (968 ppm & 937 u/ms), the third is Wartanabada (Xamar jadiid Pond) had TDS (890 ppm) and EC (1698 u/ms), and Waaber (KM4 Ponds) had TDS (810 ppm) and EC (1698 u/ms). While other districts have 500 ppm TDS. The PH ranges between 6 and 7. The samples had temperatures ranging from 32 to 33.9 degrees Celsius, which was higher than the typical temperature of 25 degrees Celsius. Total dissolved solids (TDS) in wastewater are a measure of the total amount of inorganic and organic elements present in the liquid [15] [16]. TDS in wastewater can build sediment at the bottom of the pond or be absorbed by plants, which helps lower the EC concentration. This decrease might have been caused by some of the plants that were seen [17].

The pH of the effluent is between 6 and 9, which is the range of acceptable limits for release into other habitats. According to reports, wastewater often has an acidic pH [18]. According to a reference, the ideal pH range for methanogenic bacterial development is between 6.6 and 7.6 [19]. Anaerobic conditions are said to function best at a temperature between 25 and 40 degrees Celsius, while at 15 degrees Celsius, anaerobic conditions rapidly deteriorate [20].

In Table 4, the researcher presented the water quality index after making calculations of the parameters, then presented the quality score and their grades. The grade D (poor score) was put up by Wartanabad (Xamar Jadiid Pond), Yaqshid (Warshadda Bastada Street), and Boondheer (Bondher Pond), with water quality indexes of 80.89, 80.85, and 80.64, respectively. While all other districts water samples were fair (C grade), that means they were between 50 and 75.

Table 3. List of samples of water collected from retention ponds and streets in Mogadishu.

NO.	District Location	TDS	EC	PH	Temperature
1.	Howlwadaag (Hareed Street)	481	963	6.8	32.3
2.	Hodon (Sigaale Pond)	267	535	7.0	33.1
3.	Howlwadaag (Hayaan Pond)	284	568	7.0	33.1
4.	Wadajir (Buulahubey Pond)	347	694	6.5	32.1
5.	Wartanabad (Xerta Shiekh Ali Pond)	487	974	6.8	32.0
6.	Wartanabada (Xamar jadiid Pond)	890	1781	6.0	32.2
7.	Waaber (Km4 Pond)	810	1698	6.5	32.8
8.	Boondheer (Bondher Pond)	3021	5986	6.0	32.3
9.	Wartanabad (15 may Pond)	282	565	7.0	33.9
10.	Yaqshid (Warshadda Bastada)	968	1937	6.0	32.2

Sources: Primary data.

Table 4. Samples water quality index and grades.

No	District Location	WQI	Quality score	Grade
1.	Howlwadaag (Hareed)	65.18	Fair	C
2.	Hodon (Sigaale Pond)	63.34	Fair	C
3.	Howlwadaag (Hayaan Pond)	63.05	Fair	C
4.	Wadajir (Buulahubey Pond)	71.36	Fair	C
5.	Wartanabad (Xerta Shiekh Ali Pond)	65.3	Fair	C
6.	Wartanabada (Xamar jadiid Pond)	80.89	Poor	D
7.	Waaber (Km4 Pond)	69.83	Fair	C
8.	Boondheer (Bondher Pond)	80.64	Poor	D
9.	Wartanabad (15 may Pond)	62.75	Fair	C
10.	Yaqshid (Warshadda Bastada)	80.85	Poor	D

Pictures of Collected Water Samples from Ponds in Mogadishu

As can be seen in Figure 1, they were turbid when compared to one another, which was employed to create variance in their visual appearance. Samples 5, 2, 7, 8, 1, and 11 had higher levels of turbidity than the other bottles, whereas samples 6, 4, and 3 had much less.

4.2. Rain Patterns and Prevalence of Water Associated Diseases in Mogadishu

4.2.1. Rain Patterns in Mogadishu

Deyr, or "short rains" season, runs from October to December in Somalia and is associated with the Inter-Tropical Convergence Zone (ITCZ), which regulates most of the nation's weather. There is a forecast for rainy days, with a higher likelihood of totals exceeding 150 mm. A state of emergency was declared by the federal government of Somalia in October following severe weather related to El Nino that destroyed homes, roads, and bridges. In November 2023, this happened, and the towns of Beledweyne, Baardheeer, and Baidau in Somalia had flooded streets.

Figure 2 displays the amount of rainfall in four months from September to December 2023. November has the highest amount (181.62), followed by October with 66.42, while September and December have lower amounts.

So, according to this data, the months with the highest cholera cases in Mogadishu were December, November, and October, with 451, 436, and 245, respectively, while the highest malaria cases were in December, October, and September, with cases 2018, 1133, and 1040 respectively. This suggests that cholera infections surged during the Deyr rainy season, which was linked to flash floods and pond overflows in Mogadishu.

4.2.2. Questionnaires Data Collected on Experts

Respondents were collected according to sex: male 56 (80.0%), were majority females, the age of respondents was between 25 and 30 years (30.0%), was majority,

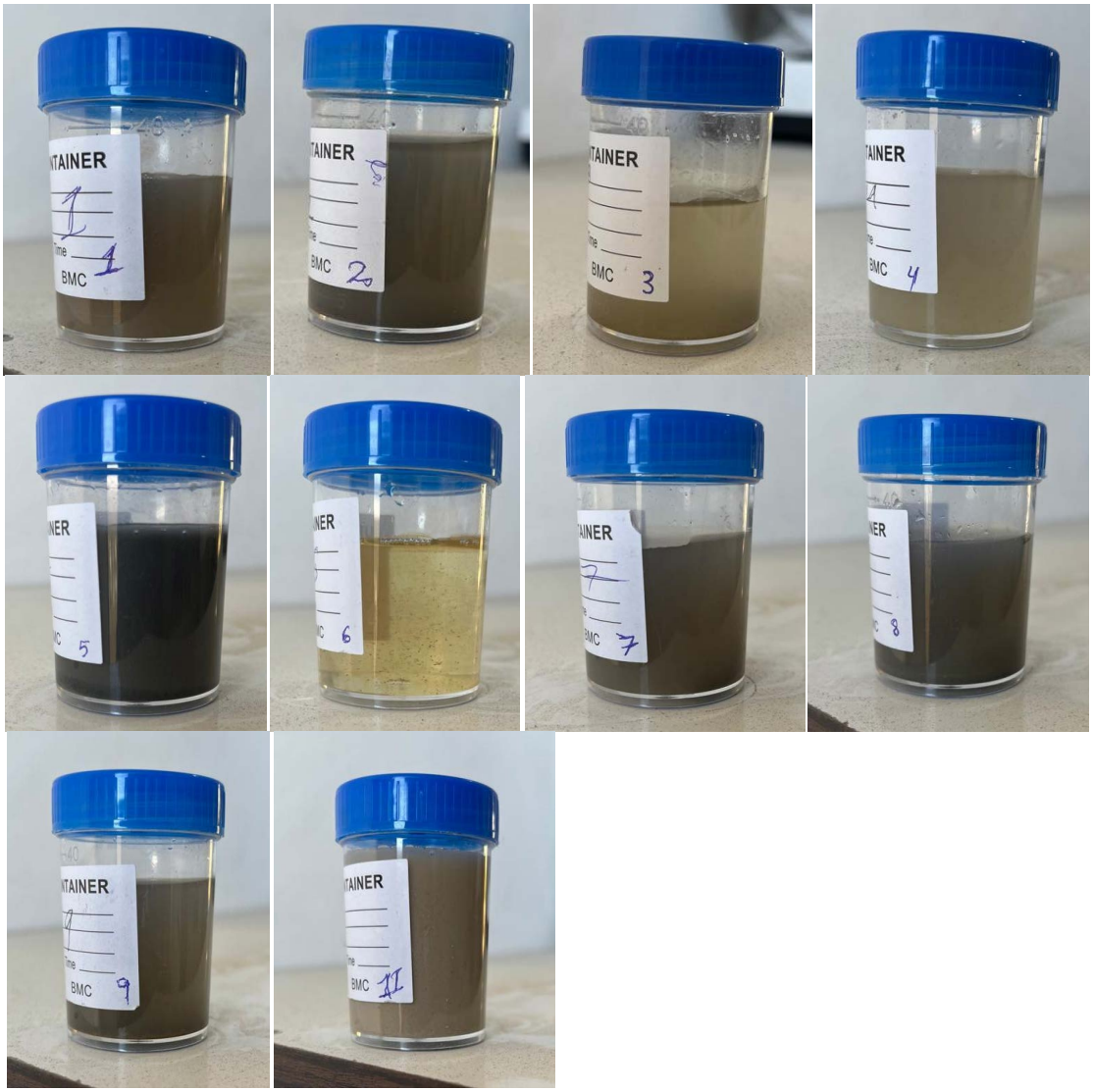

Figure 1. Physical appearance of Pond water samples collected different areas in Mogadishu, Somalia.

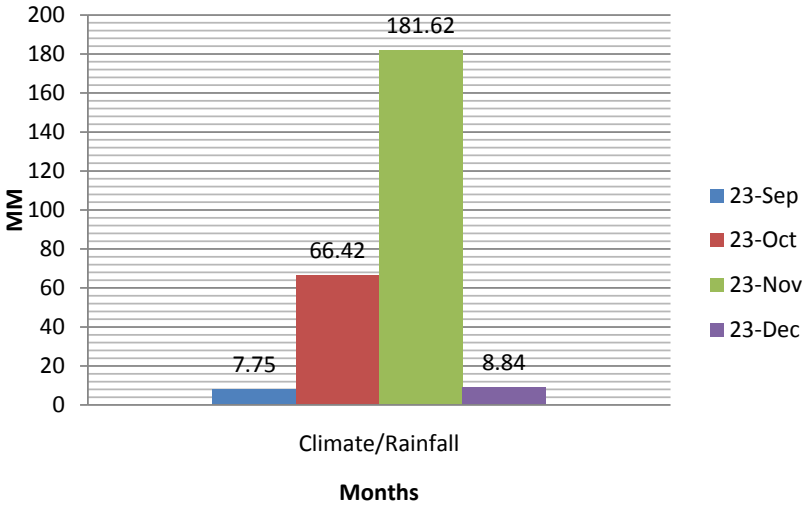

Figure 2. Rainfall in August up to December (FSNAU, 2023) [21].

while second group was between 30 and 35 (22.9%), and third group was between 35 and 40 (15.7%). The educational level of respondents was highest with a master's degree at 45 (64.3%); the second group had a bachelor's degree at 20 (28.6%); and the PhD holders were minority with 5 (7.1%). The experience of respondents was between 1 - 5 years and above in 15 groups, which have similar percentages of 20 (28.6%) in Table 5.

The overall cumulative average mean score of 4.41 and the standard deviation of 0.802 in Table 6's results show that the data are more dispersed around the mean. In the understanding of the respondents, they agreed that retention ponds have impacts on residential areas in Mogadishu, Somalia. The ponds can be sources

Table 5. Demographic characteristics of respondents.

Sex of respondents				
	N	%	Mean	Standard deviation
Male	56	80.0%		
Female	14	20.0%	1.20	0.403
Total	70	100.0%		
Age of respondents				
	N	%	Mean	Standard deviation
25 - 30	21	30.0%		
30 - 35	16	22.9%		
35 - 40	11	15.7%		
40 - 45	7	10.0%	2.79	1.676
45 - 50	9	12.9%		
50 above	6	8.6%		
Total	70	100.0%		
Educational level of respondents				
	N	%	Mean	Standard deviation
Bachelor	20	28.6%		
Master	45	64.3%	1.79	0.562
PhD	5	7.1%		
Total	70	100.0%		
Experience of respondents				
	N	%	Mean	Standard deviation
1 - 5 yrs	20	28.6%		
5 - 10 yrs	12	17.1%		
10 - 15 yrs	18	25.7%	2.56	1.211
Above 15	20	28.5%		
Total	70	100.0%		

Sources: Primary data.

Table 6. General impacts of retention ponds on environment in Mogadishu, Somalia.

Descriptive Statistics				
Items	N	Mean	Std. Deviation	Interpretation
To be Source of Mosquito	70	4.51	1.004	Strongly agreed
To be Sources of Nuisance Odor	70	4.46	0.736	Agreed
To be sources of child playing sites	70	4.33	0.880	Agreed
To be Sources of Waste Dumping	70	4.24	0.647	Agreed
Obstruction of roads	70	4.43	0.791	Agreed
Destruction beauty of environment	70	4.51	0.756	Strongly agreed
Total Cummulative Average of Mean and Standard deviation.		**4.41**	**0.802**	**Agreed**

Sources: Primary data.

of mosquitoes, nuisances, child-playing sites, waste dumping, obstruction of roads, and destruction of the beauty of the environment.

The cumulative average mean score of 4.23 and the cumulative average standard deviation of 0.725 are shown in Table 7's results. It appears that most respondents felt that retention ponds can increase mosquito-borne diseases, water diarrheal diseases, skin diseases, toxic chemical accumulation, and contamination of water sources, so that all these can have impacts on the health of the population in general areas. A significant majority of participants expressed agreement that pond water can have impacts on the health of the population.

The results in Table 8 show that the standard deviation is.826 and the overall cumulative mean score is 3.99. It is quite wide and dispersed about the mean. Thus, the management options could be used to minimize the impacts of retention ponds. The respondents agreed that the average mean score for the prevention of breeding mosquitoes is 4.17, with a standard deviation of 0.701; the average mean score for the option of making other reservoirs is 4.30, with a standard deviation of 0.938; the average mean score for the construction of urban water treatment centres is 4.26, with a standard deviation of 0.652; and the average mean score for the option of totally closing ponds is less than 3.89, with a standard deviation of 0.877.

5. Discussion

The study was conducted to determine the impacts of retention ponds on health and the environment in Mogadishu, Somalia. The first objective was to determine the contamination level of retention pond water by collecting samples of water ponds, testing physical and environmental parameters such as PH, TDS, EC, and temperature, and calculating the water quality index. So the researchers reveal that three samples received a poor score (Grade D): Wartanabad (Xamar Jadiid Pond) had a water quality index (WQI = 80.89), Yaqshid (Warshadda

Table 7. Health impacts of retention ponds on residential areas in Mogadishu.

Descriptive Statistics				
Items	N	Mean	Std. Deviation	Interpretation
Increase mosquito borne diseases	70	4.36	0.638	Agreed
Increase water diarrheal diseases	70	4.06	0.587	Agreed
Increase skin diseases	70	4.01	0.732	Agreed
Creates toxic chemicals accumulation	70	4.33	0.880	Agreed
Contaminates drinking water sources	70	4.39	0.786	Agreed
Total Cummulative Average of Mean and Standard deviation		**4.23**	**0.725**	**Agreed**

Table 8. Alternative option of managements of impacts of retention ponds.

Descriptive Statistics				
Items	N	Mean	Std. Deviation	Interpretation
Prevention of breeding mosquito	70	4.17	0.701	Agreed
Totally closure of ponds	70	3.89	0.877	Agreed
Continues Monitoring during heavy rains	70	3.84	0.862	Agreed
Make Other reservoir options	70	4.30	0.938	Agreed
Using irrigation and recreation methods	70	3.46	0.928	Neutral
Construction of Urban water Treatment centers	70	4.26	0.652	Agreed
Total Cummulative Average of Mean and Standard deviation.		**3.99**	**0.826**	**Agreed**

Bastada) had a WQI of 80.85, and Boondheer (Bondher Pond) had a WQI of 80.64, respectively. While all other samples were fair (grade), that means they were between 50 and 75.

The second objective of this study was to determine the current level of water-associated diseases prevalent and available during the Deyr rainy seasons. The data was collected on the online-based website of the Food and Agricultural Organisation (FAO), and the climate and rainfall patterns were forecast for October, November, and December during the Deyr raining season in Somalia [21]. October and November had heavy rainfall. The government of Somalia had already forecast heavy rainfall in Deyr season with El Nino. The months with the highest cholera cases in Mogadishu were December, November, and October, with 451, 436, and 245, respectively, while the highest malaria cases were in December, October, and September, with cases of 2018, 1133, and 1040 respectively. So Figure 3 indicates the cholera cases were highest in December, November and October; they have already had the highest rainfall months. While malaria

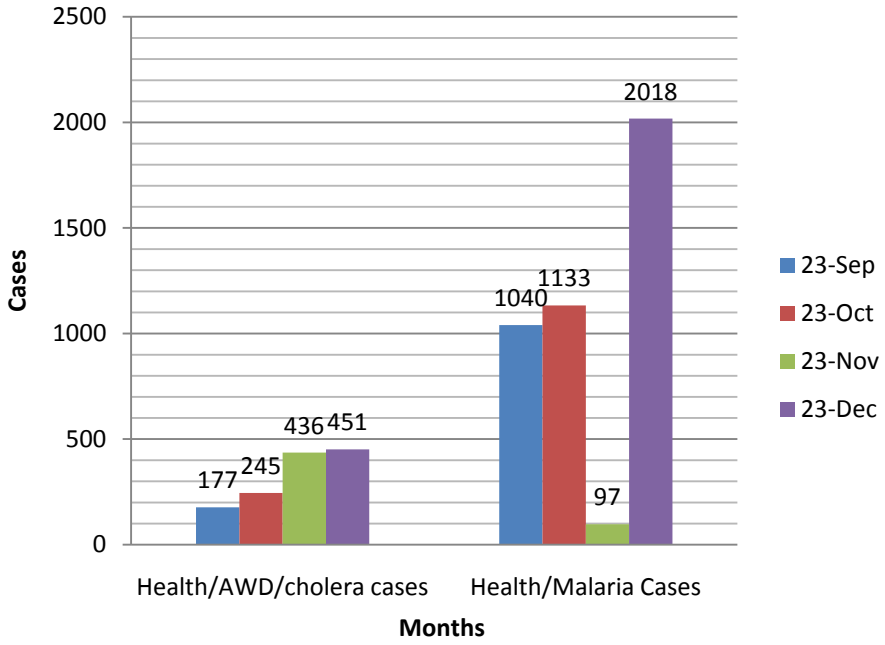

Figure 3. Prevalence of Malaria and Cholera. Secondary source: (FSNAU, 2023) [21].

cases were high in December and October but not in November or the months except August, which does not include the Deyr raining season.

The third objective was to identify the academic respondent's views and concerns about the impacts of retention ponds on the health and residential environment. So the researcher used Likert-scale methods to collect data. The first section was concerned with the general impacts of retention ponds on residential environments, so that the overall cumulative average mean scores were 4.41 and the standard deviation was 0.802. This means the respondents agreed that retention ponds have impacts on residential areas in Mogadishu, Somalia. The ponds can be sources of mosquitoes, nuisances, child-playing sites, waste dumping, obstruction of roads, and destruction of the beauty of the environment. The second section involved the impacts of retention ponds on the health of the population in Mogadishu, Somalia. So that the cumulative average mean score was 4.23 and the cumulative average standard deviation was 0.725. It seems that most respondents felt that retention ponds can increase mosquito-borne diseases, water diarrheal diseases, skin diseases, toxic chemical accumulation, and contamination of water sources, so that all these can have impacts on the health of the population in general areas. In the last section, we asked the respondents about alternative options for managing the impacts of retention ponds on health and environments in Mogadishu, Somalia. So the cumulative average of the standard deviation was 0.826 and the overall cumulative mean score was 3.99. Thus, they agreed on all management options taking the highest ranking, including the prevention of breeding mosquitoes, making other reservoirs, the construction of urban water treatment centres, and the total closure of ponds. The first option was to prevent mosquito breeding by using all other suitable methods of reducing

mosquito breeding in retention ponds. In order to evaluate rainwater harvesting interventions as viable choices in land and water resource management activities for human well-being and ecosystem productivity, rainfall must be regarded as a significant, manageable resource in water management policies, strategies, and plans [22].

6. Conclusion and Recommendation

The study concludes that the water quality of retention ponds consists of high contamination, reaching Grades D and C (poor and fair). The retention ponds have indirectly related to the prevalence of water-associated diseases (cholera and malaria) because rainfall and overuse of retention ponds create high cases of those diseases in the Mogadishu. The academic experts agreed that retention ponds can impact the general residential environment. Also, they agreed on four alternative options for the management of retention pond impacts in Mogadishu. They list the prevention of breeding mosquitoes, the construction of urban water treatment centres, and the total closure of ponds.

The study recommended the Ministry of Health make a committee on public health at the district level to determine the contamination of retention ponds and make treatment units for its management. The local government must make a sewer system in all districts and add the facilitation of retention ponds to transport them elsewhere outside the city. The community must make simple alternative options to prevent mosquito breeding during each rainfall and sluge management after rain. The government must re-construct retention ponds in size and depth to prevent overflow during rain in residential communities.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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