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Evaluating the Environmental and Public Health Impacts of Urban Domestic Liquid Waste Generation in Addis Ababa, Bulbula Treatment Plant, Ethiopia

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Abstract – *With an emphasis on condominiums in Bole Sub City, this study evaluated the production, disposal, and effects of domestic liquid waste (DLW) in Addis Ababa. The city's wastewater infrastructure was overburdened by the rapid urbanization and population increase; the Bulbula wastewater treatment facility was only using 23.67% of its 3,000 m^3/day capacity. Only 24.8% of condominium homes had sewer connections, and every day, over 372.01 m^3 of untreated or insufficiently treated DLW was released into the environment. Environmental testing showed that the Bulbula River's water quality has seriously deteriorated. Biological Oxygen Demand (BOD) values reached 90 mg/L, 50% above allowable limits, and Chemical Oxygen Demand (COD) levels of 200–250 mg/L above WHO requirements by up to 53.3%. Some samples had an E. coli concentration that was more than 12 times higher than what was considered tolerable, indicating serious contamination. Impacts on public health were noteworthy, with digestive and respiratory disorders being among the most common illnesses in the region. It was calculated that the annual cost of treating these illnesses was 6,973,750 ETB, or roughly 55,790 USD.The results emphasized the critical need for community awareness campaigns, regulatory enforcement, and infrastructural improvements to address DLW mismanagement and lessen its negative effects on the environment and human health.*

Keywords: Domestic Liquid Waste (DLW), Wastewater Treatment, Environmental Impact, Public Health Risks.

1. INTRODUCTION

Global population increase and urbanisation are causing waste management systems to face previously unheard-of difficulties, especially in emerging nations' cities. Domestic liquid waste (DLW) is a major problem for cities around the world. A large portion of this trash is left untreated, which has a negative impact on the environment and human health [1].The situation is particularly severe in sub-Saharan Africa since urban centres grow quickly, frequently surpassing the construction of suitable wastewater infrastructure. The effects of untreated liquid waste on land, aquatic bodies, and air quality are worsened by inadequate treatment facilities and legal frameworks [2].Addis Ababa, Ethiopia, is a prime example of this difficulty. Being the capital and biggest city in the nation, its expanding population and urbanisation have put too much strain on the wastewater system. Significant issues with the environment and public health have resulted from this, especially in places like the Bulbula Treatment Plant. Uncontrolled production and inappropriate disposal of household liquid waste endanger ecosystems, contaminate water supplies, and raise the incidence of waterborne illnesses in local populations [3, 4]. Urbanization and population growth have placed immense pressure on existing wastewater infrastructure in Addis Ababa, Ethiopia. Bole Sub-City Condominiums generate significant domestic liquid waste, approximately 372.01 m^3 daily. Households either connect to the city sewer system or use vehicles for onsite waste management. Condominium houses produce 50,715,335 liters of liquid waste daily (93.5 l/d/p). Only 24.8% of houses are sewer-connected, with 24,400 m^3 of effluent entering the Kality treatment plant [5].

This has led to the unchecked generation and improper disposal of domestic liquid waste (DLW), posing a severe environmental and public health threat [6]. Liquid waste generation in Addis Ababa is a major concern due to the lack of proper infrastructure and facilities for waste management [5]. The city's limited sewerage coverage system is unable to cope with the increasing volume of liquid waste generated by households, industries, and commercial establishments. As a result, a significant portion of the liquid waste ends up being discharged into open drains, rivers, and other water bodies, leading to environmental pollution and public health risks [7]. The improper disposal of DLW has far-reaching environmental consequences (FAO, 2012). Contaminated wastewater infiltrates the soil, introducing harmful chemicals and pathogens that can contaminate crops and pose health risks to consumers. Additionally, untreated wastewater entering water bodies leads to eutrophication, an excessive nutrient overload that depletes oxygen levels, harming aquatic life and disrupting ecosystems [8].

The consequences of unchecked DLW generation extend beyond environmental degradation, posing significant public health risks [9].Water pollution not only harms health but also increases medical costs, exacerbating urban poverty. Contaminated water serves as a breeding ground for harmful microorganisms, causing waterborne diseases like diarrhea,

cholera, and typhoid outbreaks [10].These illnesses disproportionately impact vulnerable populations, particularly children and the elderly, causing substantial morbidity and mortality. Urban and peri-urban vegetable production in Ethiopia is vital for food security and income for poor urban communities. However, limited government funding and household health expenses as user fees hinder access to healthcare [11].

The poor management and improper disposal of domestic liquid waste pose significant environmental and public health risks in Addis Ababa, particularly in Bole Sub City condominiums, amid rapid urbanization and inadequate wastewater infrastructure development[12]. This strain results in frequent overflows, leaks, and discharge of untreated or under treated wastewater into the environment, contaminating vital water sources, including rivers and groundwater [13, 14] .One of the primary challenges lies in the inadequate infrastructure and services for waste management, exacerbated by rapid population growth and urbanization. As highlighted by Mekonnen and Argaw (2019) [15], Current sewage systems and treatment facilities cannot cope with the rising liquid waste from the growing population. Socio-economic issues like poverty and lack of awareness worsen improper disposal practices, increasing environmental pollution and public health risks [16]. The ways that domestic wastewater is collected, disposed of, and treated before being released into natural water sources determine how wastewater affects the environment. Because of their economic and ecological importance, authorities should increase the energy efficiency of treatment plants in order to lessen this effect [17].

Mismanagement of domestic liquid waste leads to environmental degradation beyond water and air pollution, harming ecosystems. Eutrophication, caused by untreated wastewater entering water bodies, results from excessive nutrient overload [18]. This nutrient overload triggers excessive algae growth, leading to the depletion of oxygen in the water, harming aquatic life and disrupting the delicate balance of ecosystems [19]. The introduction of untreated wastewater promotes invasive species, disrupting ecosystems and causing ecological imbalances.

The economic losses associated with unchecked Domestic Liquid Waste (DLW) generation and improper disposal are substantial. Increased healthcare costs, and decreased property values are just a few of the economic repercussions [20]. A crucial sector of Addis Ababa's economy is affected by perceived environmental degradation and health risks, leading to increased healthcare costs from treating waterborne diseases linked to Domestic Liquid Waste contamination [21]. Additionally, property values in areas affected by DLW pollution are likely to depreciate, impacting the overall economic well-being of communities.The main objective of this research is to improve environmental and public health in Addis Ababa, Ethiopia, especially in Bole Sub-City condominiums, by examining urban domestic liquid waste challenges. It evaluates the Bulbula wastewater treatment plant's effluent impact on Bulbula River as an indicator of DLW effects on health and the environment. By adjusting waste and environmental management programs to users' expectations and situations, the study's conclusions will enable policymakers, service providers, waste planners, and environmental authorities to improve efficient waste management methods [22].

2. Materials and Methodes

2.1. Study Area

As shown in (Fig.1), Addis Ababa is located in central Ethiopia at 8^0 45’ to 9° 5'38.48"N north latitude and 38^0 34’’to 39^0 4’ east longitude It is the biggest city in Ethiopia with a population of 5.7million as of 2024 [23]. Addis Ababa was established 139 years ago and has since expanded into a 546 km^2, heavily populated metropolis encircled by volcanic highlands. With its steep slopes and rapids, the Entoto Ridge in the north creates a watershed boundary between the Awash and Blue Nile basins. From 3003 meters at Entoto to 2000 meters at Akaki, the water flows from north to south.

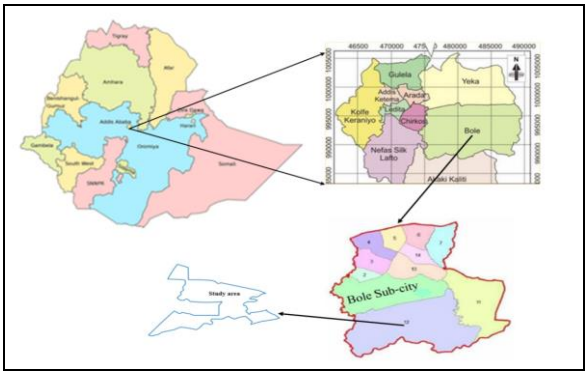

Fig. 2: Location map of the research area

2.2. Research Design

The research applied a cross-sectional study design to assess the current state of domestic liquid waste generation, disposal and treatment in Bole Sub city Condominiums as shown in (Fig.3). This design allowed the collection of data from the Addis Ababa water and sewer authority, Environmental protection authority and laboratory testing of treated effluent.

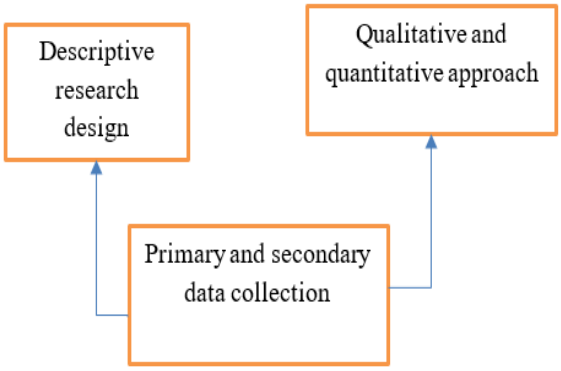

Figure 4: Graphical representation of Research Design and Methodology

2.3. Data Collection Methods

Both primary and secondary data were used in the investigation. The Addis Ababa Water and Sewer Authority contributed secondary data on wastewater treatment and infrastructure, and the local government supplied information on housing and population. The analysis was supplemented by laboratory tests and health effect data from Bulbula Health Centre. A lab test was conducted to check the pollutant level of the wastewater and the river water itself [24, 25]. The turbidity, pH, conductivity, BOD, COD, TDS, and coliform count of water samples were tested at the Addis Ababa Environmental Protection Authority and Water and Sewer Authority laboratories. The tests aimed to evaluate whether the treatment plant's effluent adversely affects the river, comparing results to WHO guidelines for natural surface water to protect aquatic life.

3. Results and Analysis

The findings from the study reveal several key insights regarding domestic wastewater generation patterns and practices, its impact on the environment and people. The findings of the research are given as follows.

3.1. Domestic liquid waste generation

3.1.1. Existing Treatment plants in Addis Ababa

According to the Addis Ababa Water and Sewer Authority 2023[26] annual report there are about 43 (22 An anaerobic baffled reactor (ABR), 5 Waste Stabilization Ponds (WSPs) and dry bed , 12 Membrane Bioreactor (MBR), 2 Up flow anaerobic sludge blanket reactor (UASB)r + trickling filter (TF), 1 Wetland and 1 CAS (conventional Activated sludge),wastewater treatment plants in Addis Ababa under the auspices of the authority. Among these 3 are currently not functional and about 8 are standby and 2 dry bed plants for vacuum truck carry and dump system. The remaining 30 plants are functional with design capacity of filtering 197,047m^3/day. The current actual capacity of treatment is 121,050 m^3/day Addis Ababa Water Aouthority (AAWA 2023), as shown in (Fig. 5).

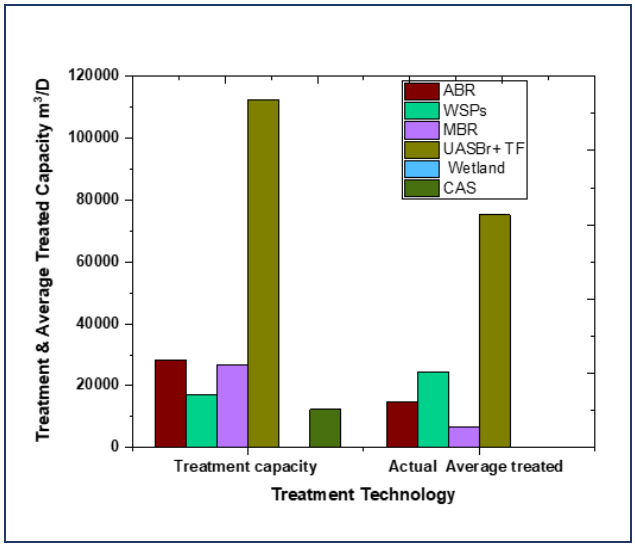

Fig. 6: Liquid waste treatment plants run by AAWSA in Addis Ababa (26)

Due to low flow and maintenance problems, the Membrane Bioreactor (MBR) plant in the Bulbula condominium neighborhood only functions at 710 m^3/day, or 23.67% of its capacity. The MBR plant was supposed to operate at 3,000 m^3/day. With the maximum capacity of 197,047 m^3/day and an average treated volume of 121,050 m^3/day, Addis Ababa Water and Swer Aouthority (AAWSA's) treatment plants are highlighted in a graph. Significant underuse is evident in some plants, such as one with a capacity of 28,320 m^3/day, which barely treats 14,600 m^3/day. This provides information on the effectiveness of the city's wastewater management system by reflecting differences in facility size and performance. The treatment plant is located at the southern tip of the condominium site at absolute location of 38.787473^{0}E and 8.9434983^{0}E.

3.2. Domestic Liquid Waste Generation within the study area

The Bulbula condominium site is located in Addis Ababa, Bole-sub-city between 38.78414^0 and 38.796865^0 East and between 8.943546^0 and 8.954334^0 North with the total area of 39.1 ha. The site consists of 175 blocks and 4,481 occupied housing units. The Addis Ababa Water and Swer Aouthority (AAWSA) monthly liquid waste production of 11,160.33 m^3, averaging 372.01 m^3 daily. With a population of 20,165 residents, this results in a per capita wastewater production of 16.34 liters per person per day, which is lower than the Sub-Saharan Africa average of 30.36 liters [27]. Bulbula Condominium faces water shortages, with supply available only three days a week for 12 hours. Limited rooftop reservoirs force households to store water in barrels and flush toilets manually. The sewer network, consisting of 110mm PVC pipes, collects wastewater to the

treatment plant. Blockages at manholes require bi-monthly drainage services. The treatment plant operates at just 23.67% capacity, handling 372.11 m^3/day.

3.3. Environmental Impact

The research examined the environmental effects of wastewater from the Bulbula site on the Bulbula River. Effluent from the treatment plant was analyzed, with samples collected from three locations, including one (Sample A) taken before mixing with the river. The absolute location of point A is 38.787843°E and 8.940735°N. The second sample (Sample B) was collected from the Bulbula River, approximately 1 km upstream of the effluent discharge, indicating the river's condition before the treated effluent mixes in. The absolute location of point B is 38.799857°E and 8.946117°N.The third sample (Sample C) was collected about 1km downstream after the river and the treated water has been thoroughly mixed. The absolute location of point C was 38.781919°E and 8.936810°N. This part is expected to indicate the impact of the treated water on the water quality of the river.

The pH value of water is closely related to its concentrations of carbon dioxide (CO2) and alkaline substances [28]. In this study, pH values were alkaline, ranging from 7.99 to 8.03, with no significant difference between treated effluent and river water, as shown in (Fig.7**)**.This indicates low CO2 levels, which generally reduce pH. Research on pH's effects on food and waterborne pathogens is increasingly prevalent in laboratory and uncontrolled settings [29]. The pH of pharmaceutical wastewater from various batch processes can significantly vary, ranging from very acidic to alkaline, often due to detergent residues like sodium-based soaps present in the treated water [30]. The river water's pH exceeds that of the treated effluent, potentially influenced by additional effluent from the Bole Lemi industrial park, located 8 km upstream. Further research is necessary to evaluate the impact of this industrial discharge.

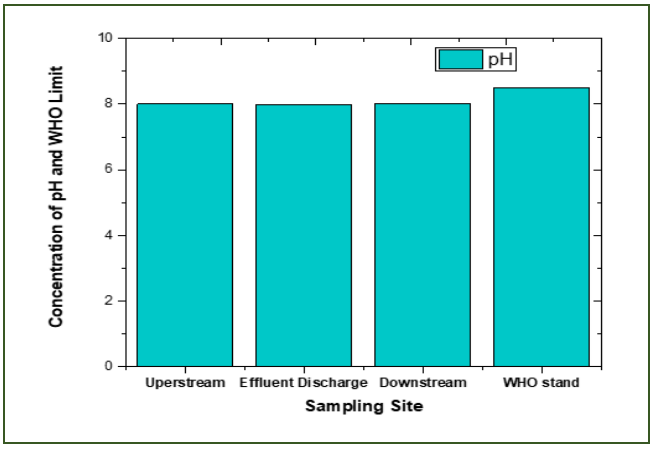

Fig. 8: lab test result of pH

As shown in (Fig.9) Turbidity measures water clarity; higher turbidity indicates cloudier water. Various materials cause turbidity, including silt, organic and inorganic matter, clay, algae, and microscopic organisms. The turbidity test result indicates that it ranges from <20 to 142 NTU (figure 2). Turbidity can hinder sunlight penetration to the water's surface, limiting photosynthesis in aquatic plants and potentially causing cascading effects throughout the entire ecosystem [31]. High turbidity can impair the vision and breathing of fish and other aquatic organisms, as it may clog their gills, making respiration difficult [32]. Turbid water absorbs more sunlight, leading to increased water temperatures. This can stress aquatic organisms and reduce their oxygen levels [33]. Water turbidity influences pollution levels in rivers. Our tests showed that the least turbid water originated from the treatment plant discharge, demonstrating its effectiveness in eliminating suspended solids that contribute to turbidity.

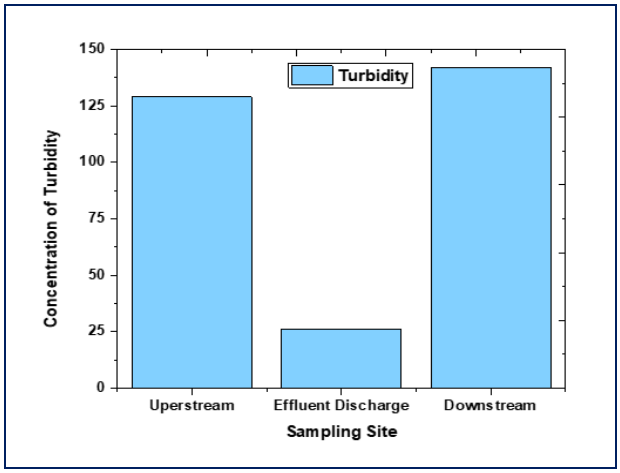

Fig. 10: lab test result of turbidity

Conductivity indicates water's electrical conductivity; higher dissolved salts and inorganic chemicals increase salinity, reflecting a greater concentration of dissolved substances [34]. Water conductivity can be affected by minerals in the waterbed, agricultural runoff, urban runoff, and industrial effluent.As shown in (Fig.11), the highest conductivity recorded was 1075 µs/cm in the effluent discharge, while samples B and C had values around 450 and 510 µs/cm. Notably, the effluent's conductivity exceeded both upstream and downstream measurements. The mixing of the highly conductive effluent with upstream water led to a lower downstream conductivity of 510 µs/cm, likely due to dilution from additional discharges or mineral-absorbing algae reducing mineral levels between points A and C.

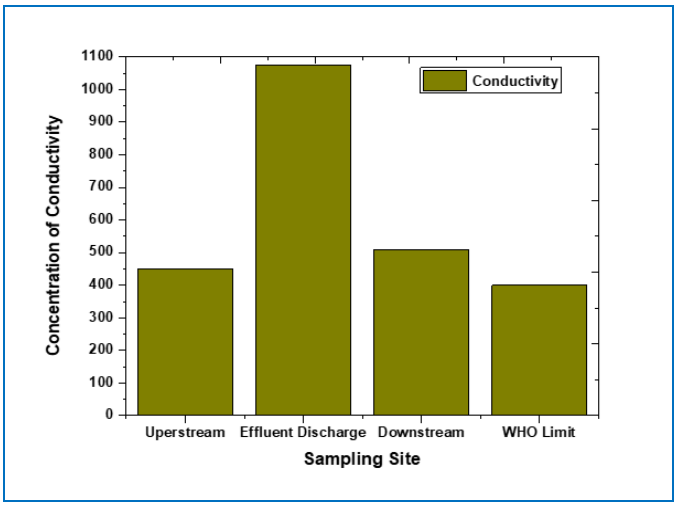

Fig. 12: Lab result of Water Conductivity

Chemical Oxygen Demand (COD) measures the oxygen needed to oxidize organic matter in (Fig.13), Water indicating total organic pollution. High COD levels suggest significant pollution, depleting dissolved oxygen and harming aquatic life, particularly fish and organisms reliant on oxygen for survival [35, 36]. High organic matter levels can lead to eutrophication, causing excessive nutrient buildup in water that triggers algal blooms. These blooms deplete oxygen, resulting in fish deaths and making the water unpleasant for use [37]. The test results of COD levels vary according to test results. The Water and Sewer Authority's findings confirmed low treatment efficiency, whereas the Environmental Protection Authority found increased COD from samples A to C. Significant contamination was indicated by samples A, B, and C, all of which recorded 200 mg/l, 250 mg/l, and 230 mg/l, respectively, above the WHO's 150 mg/l standard.

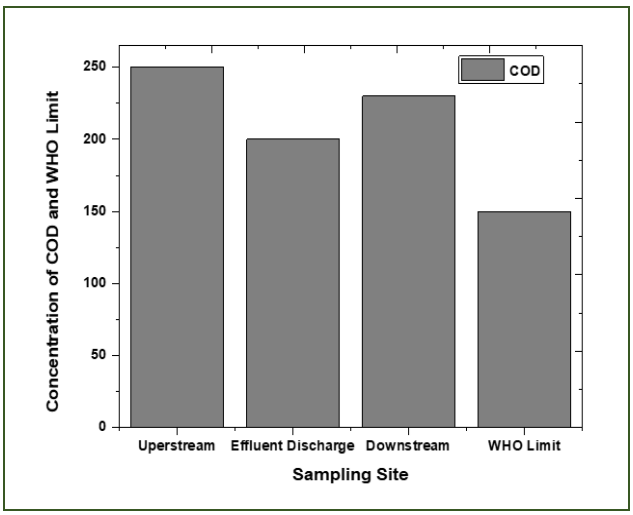

Fig. 14: Chemical Oxygen Demand (COD) and Water Pollution

As shown in (Fig.15), BOD measures the oxygen required by microorganisms to break down organic matter in water, indicating pollution levels. High BOD suggests significant organic waste, depleting oxygen, while low BOD indicates better water quality [38-40]. BOD levels are highest in upstream and downstream samples and lowest at the discharge site. Sample A recorded 85 mg/l, while Samples B and C reached 90 mg/l. These results indicate significant contamination from untreated sewage or industrial waste, necessitating quick action. The WHO standard is 60 mg/l.

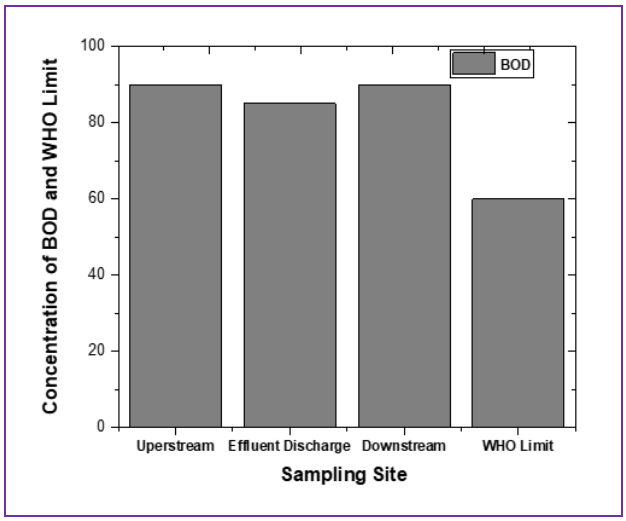

Fig. 16: Biochemical Oxygen Demand (BOD)

E. coli is a bacteria commonly found in the intestines of warm-blooded animals, including humans (Fig.17). While many strains are harmless, some can cause serious illnesses. The presence of fecal coliform bacteria in water indicates contamination from warm-blooded animal feces[41]. This means that the water has likely been contaminated with human or animal waste. Fecal contamination can introduce a variety of harmful pathogens into the water, including[42]. Because of dilution, E. coli levels are moderate downstream, lowest at the effluent discharge, and highest upstream. Sample A recorded 180 MPN/100 ml, Sample B 1600 MPN/100 ml, and Sample C 920 MPN/100 ml, above the WHO limit of 126 MPN/100 ml. Every sample has levels above safe limits, necessitating prompt source protection and remediation actions.

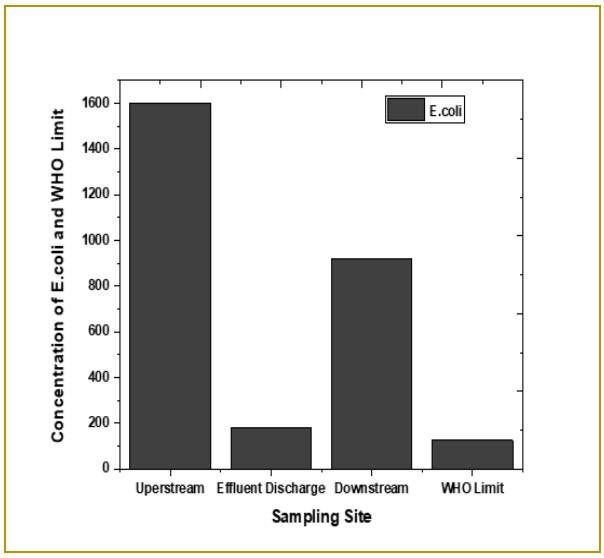

Fig. 18: Lab Result of E.coli count MPN/100ml

Total dissolved solids, or TDS, are a measure of the salts and minerals in water.To evaluate the effects of humans and the environment on water quality, it is essential to monitor TDS and other indicators[43],as shown in (Fig.19). Aquatic ecosystems and wastewater treatment are impacted by high TDS levels. The effluent from the treatment plant exhibits excessive TDS, which could be the result of an ineffective membrane that is eight years old or increased use of household products. Elevated TDS endangers aquatic life and disturbs ecosystems by stressing freshwater species, encouraging algae blooms, and reducing oxygen levels. For mitigation, proper upkeep and monitoring are essential.

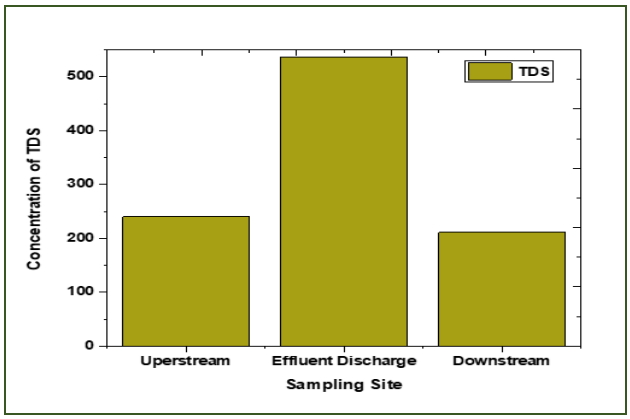

Fig. 20: Lab test result of Total Dissolved Solids (TDS)

3.3.1. Variations of microbiological parameters of sampling sites

The study evaluates effluent and downstream water quality to assess environmental impact, using WHO standards as a control. A one-tailed paired t-test showed treated water quality below WHO standards for natural water, with a p-value of 0.099789, supporting the hypothesis. This indicates the effluent does not meet WHO minimum requirements. The test also compares upstream (natural) and downstream (contaminated) water quality parameters, highlighting the effluent's effect on water quality. Results are shown in (Fig.21). If no difference exists, the treatment plant effectively treats waste without environmental impact. However, a significant difference indicates effluent discharge is degrading river water quality, highlighting the plant's impact on the environment. Accordingly the p value obtained on a 1 tail paired t-test was 0.325 and 2 tail t-test was 0.65 which is greater than the conventional 0.05 (95%) confidence interval. This indicates that there is no significant difference between the upstream water and the downstream water. However the test results of the effluent discharges at A, the upstream at B and the downstream at C all have not fulfilled the WHO standard for natural surface water. Test results confirm that Bulbula River water is already contaminated, evident by the lack of aquatic life. Since the river is polluted before reaching the Bulbula wastewater treatment plant, the plant's discharge does not affect water quality. A treatment plant at Bole Lemi Industrial Park, 8 km upstream, may influence river contamination. Public concern is high, with 61% worried about water contamination and 68% reporting unpleasant odors.

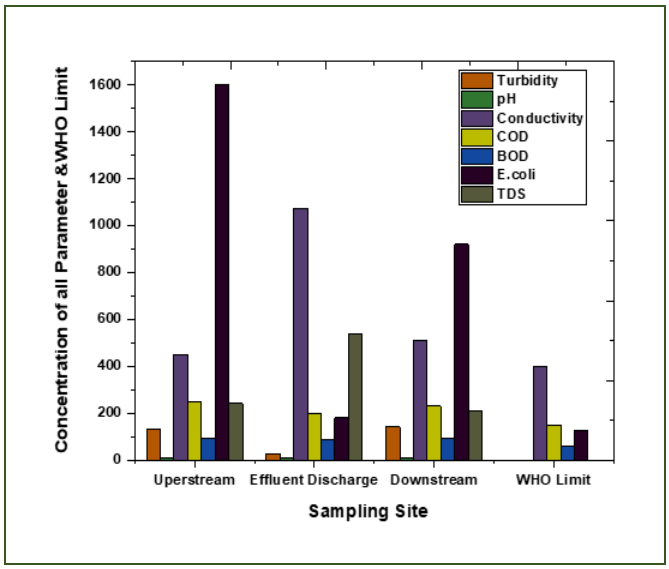

Fig. 22: Variations of microbiological parameters of sampling sites

3.4. Comparision of Organic Pollution Indicators

Research on Addis Ababa's water quality reveals significant variations in parameters like pH, turbidity, E. coli, TDS, COD, BOD, and electrical conductivity due to differing sample sites, environmental sources, and human influences as shown in (Table.1). In 2022, Solomon Tibebu reported pH levels of 6.7–8.1, moderate BOD (51 mg/L), and COD (68 mg/L), indicating organic pollution. Turbidity reached 850 NTU, reflecting substantial sedimentation. E. coli

concentrations were concerning at 737 CFU/100 mL, likely due to untreated sewage or runoff [6].

In contrast, this study revealed alarming pollution levels, with BOD ranging from 85 to 90 mg/L and COD peaking at 250 mg/L. Turbidity reached as high as 1600 NTU, indicating severe particulate matter contamination from urban runoff. E. coli levels were also elevated at 129 CFU/100 mL, alongside electrical conductivity readings of 450 to 1075 µS/cm, posing serious public health risks. Other studies, such as those by Gizaw Ebissa (2024)[44] noted varying COD and turbidity levels that still indicated significant pollution challenges requiring urgent intervention. Similarly, Terusaw Solomon (2024) [45], reported elevated COD levels of up to 418 mg/L and turbidity reaching 228 NTU, indicating significant water quality concerns despite being lower than this study findings.

As opposed to, Thandile T. Gule (2023) [46], found relatively low turbidity and salinity values, indicating less polluted water sources, although the study's limited scope reduced its comprehensiveness compared to others. High organic pollution and turbidity were consistent issues, with this study findings showing the contamination. Elevated COD, turbidity, and E. coli levels highlight wastewater treatment challenges. Notable EC variations indicate salinity differences, emphasizing the need for integrated water management and pollution control. These findings underscore the need for integrated water management and pollution control to ensure safe water for the growing population.

Table 2: Comparision of Organic Pollution Indicators

No.	location	Data colected year	Parameters							reference
			pH	BOD (mg/l)	COD(mg/l)	Turbidity (NTU)	Ecoli (MPN/100ml)	TDS (mg/l)	E.conductivity (µs/cm)	
1	Addis ketma subcity Addis Ababa,Ethiopia	2022	7.4	39.5	58			617	1204.5	[1]
2	Addis Ababa Bole subcity ,Ethiopia	2024			157.5			569		[40]
3	Mekanisa-Gofa-Lafto Addis Ababa,Ethiopia	2024	7.61	122	223.3				2.75	[41]
4	Legedadie,Addis Ababa, Ethiopia		14.79			53.88	0.736		8.53	[42]
**	Addis Ababa Bole subcity,Ethiopia	2024	8.01	88.3	226.6	99.06	900	329.2	678.3	This study

3.5. Health Impact of improper DLW handling and disposal

As shown in (Fig.23), improper liquid waste handling and disposal negatively affect residents' health in several ways. It can lead to air quality deterioration, causing respiratory diseases, and create breeding grounds for insects, impacting surface water quality. At Bulbula Health Center, respiratory tract diseases ranked 6th, and intestinal diseases 5th among the top 10 common illnesses, suggesting a link to improper waste management. Actual disease incidence may be higher, as health centers are often the first point of contact for medical care in Ethiopia.

However, many individuals may choose to visit hospitals instead, anticipating better quality care despite the higher costs associated with hospital visits [47]. This trend is particularly evident in urban areas, where wealthier households and urban residents are more likely to utilize hospital services compared to those in rural settings ([47], [48]).

The preference for hospital care over local health centers can exacerbate health disparities, particularly in low-income communities where access to quality healthcare is limited ([47, 48]). Moreover, the underutilization of health centers can lead to an underreporting of health issues related to waste management, as individuals may not seek care for mild symptoms or may attribute their health problems to other causes[49]). This situation is compounded by the fact that health centers often the lack of resources and infrastructure in health centers often discourages residents from seeking treatment for health issues caused by poor waste management practices([50]).

The implications of these findings underscore the need for improved waste management strategies and public health education to address the health risks associated with improper liquid waste handling in the community[51].

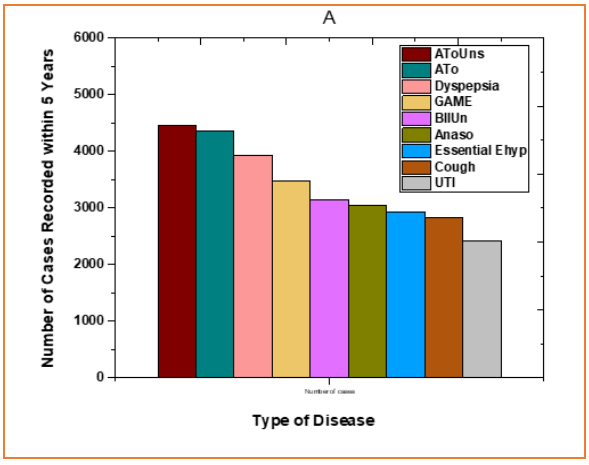

Figure 24: Top 10 Diseases Recorded June2020- 2024 in Bulbula Health Center (N.B. Acute tonsillitis, unspecified (AToUns),Acute tonsillitis (ATo), Dyspepsia, General adult medical examination (GAME), Bacterial intestinal infections, unspecified (BIUN),Acute nasopharyngitis (Anaso),Essential hypertension (Ehyp),Cough, Examination for driving license (ExaDL),Urinary tract infection, site not specified (UTI))

According to the Bulbula health center annual report treatment of intestinal infection (the 5th top 10) would cost about 200ETB or 1.66$ for lab test and medicine, however it takes about 7 days to complete treatment during which the patient would be off work. The minimum paid daily casual worker earns about 150ETB or 1.25$ per day and loses about 150*7 = 1050ETB or 8.75$ in a week during his sick period. As a result the economic loss of a person suffering from intestinal disease would lose 200 +1050 = 1250 ETB or 10.4$ apart from morbidity, physiological, and psychological discomfort. As depicted on figure 14 above the total cases of intestinal infection in a year was 3147 persons. When this multiplied by the per capita treatment related expense of 1250Birror 104$ equals 3,933,750Birr or32781.2$. Acute naso-pharyngitis, the 6th most common disease likely caused by odor and air pollution from wastewater mismanagement, affects 3,040 patients. Treatment costs about 250 ETB ($2.08), and patients lose 5 workdays, which on the basis of a daily labourer income amount to 5days * 150ETB or 1.25$ costing 750 ETB ($6.25).The total cost of the naso-pharyngitis treatment and off work compensation equals 1000ETB or 8.33$. When this multiplied by the number of patients (3040) equals 3,040,000 ETB or 25333.3$. The economic loss from the water and airborne disease as a result of wastewater mismanagement would be 6,973,750 ETB which is approximately 55,790 USD.

4. Recommendations

Targeted initiatives are essential to tackle the environmental and public health challenges posed by domestic liquid waste (DLW) in Addis Ababa, particularly within the Bole Sub City condominiums.

1) The Bulbula treatment plant operates at just 23.67% of its 3,000 m^3/day capacity, discharging 372.01 m^3 of untreated wastewater daily, emphasizing the need for urgent infrastructure upgrades.

2) Improving capacity with advanced technologies like membrane bioreactors could enhance efficiency. With only 24.8% of households connected to sewers, expanding the network to the remaining 75.2% is essential. Frequent blockages, occurring twice monthly, highlight the importance of regular maintenance. To address high COD and BOD levels exceeding limits by 33% and 41.7%, respectively enforcing WHO standards and implementing real-time monitoring is critical for pollution control.

3) Public education campaigns are required to raise awareness among the 68% of residents experiencing odor issues and the 61% concerned about water pollution. Community engagement programs could promote effective waste management practices.

4) Finally, preventive measures and enhancements to local healthcare systems are necessary to address the annual economic loss of 6,973,750 ETB (approximately 55,790 USD) associated with health impacts. A comprehensive strategy integrating community initiatives, policy reforms, and infrastructure improvements is vital for mitigating DLW-related challenges.

5. Conclusions

The research findings reveal that domestic liquid waste generation at the Bulbula Condominium site is relatively low, primarily due to two main factors: water scarcity and residents' awareness of water costs. This study focused on condominiums in Bole Sub City, analyzing the production, disposal, and effects of domestic liquid waste (DLW) in Addis Ababa. It highlighted significant issues stemming from the city's wastewater infrastructure being overwhelmed by rapid urbanization and population growth.

1).The Bulbula wastewater treatment plant managed only 710 m^3/day of its 3,000 m^3/day capacity, functioning at just 23.67%. Consequently, approximately 372.01 m^3 of untreated or inadequately treated DLW was released daily into the environment. Only about 24.8% of households had sewer connections, while the rest relied on manual collection or untreated disposal methods.

2).The study found that the Bulbula River, receiving this effluent, was severely contaminated, with Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) levels recorded at 200 mg/L and 85 mg/L,respectively exceeding World Health Organization (WHO) surface water limits by 33% and 41.7%. E. coli levels exceeded permissible limits by 42.9%, reaching 180 MPN/100 ml, causing severe environmental impacts like eutrophication, disrupting aquatic ecosystems, and reducing biodiversity.

3).The study linked contaminants to rising intestinal and respiratory illnesses, leading to significant economic losses. It also highlighted inefficiencies in wastewater treatment, emphasizing the need for community involvement, policy changes, and infrastructure upgrades to improve waste management.

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