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Assessment of drinking water quality and hygiene practice status in the areas of Muktagacha Municipality in Mymensingh district of Bangladesh

Mrittika Das Durba[1], Md. Rakibul Hassan[2*]
[1] Department of Environmental Science and Engineering, Jatiya Kabi Kazi Nazrul Islam University, Trishal, Mymensingh, Bangladesh
[2] Assistant Professor, Department of Environmental Science and Engineering, Jatiya Kabi Kazi Nazrul Islam University, Trishal, Mymensingh, Bangladesh

Abstract
Muktagacha Upazila is located in the north-central region of Bangladesh. This study was to evaluate the drinking water quality and hygiene practice status of Muktagacha Municipality. From 27 different locations of 9 Wards, water samples were collected in Muktagacha Municipality. A cross-sectional field survey design was conducted to gather data related to water supply, sanitation, and hygiene practice status in the area. It was found that the levels of DO, p^H, EC, TDS from the water samples were within or near to standard level for drinking. But in bacteriological test, some water samples exceeded their standard limit. Most of the people in Muktagacha rely on submersible pumps for drinking water, some others use tube wells and a few people depend on supply water. The study found that there were inadequate sanitation infrastructure and poor hygiene conditions in many places. A significant number of people do not use dustbins to dispose of their waste. Contaminated water sources and poor hygiene behaviors have contributed to waterborne illnesses. Improving the drainage system, implementing efficient waste management measures and promoting hygiene education programs are essential for ensuring good hygienic conditions as well as enhancing the quality of public health.

Keywords: Water quality, sanitation, hygiene and waste management

Introduction

Safe water is a fundamental resource for human being and vital component for maintaining proper hygiene, sanitation and daily life. Recognizing these rights as human rights in 2010, United Nations General Assembly (UNGA) called on countries to support developing countries in accessing to safe, affordable, and clean drinking water and sanitation (United Nations, 2015) [19]. A major risk to public health is the spread of water-borne illnesses brought out by inadequate sanitation. The absence of accessible sanitation facilities continues to hinder the implementation of standard hygiene practice (Badhan, 2017) [5]. Human waste contaminates waterways, fostering the growth of pathogens such as bacteria, viruses, and parasites if sanitation is not properly practiced. As a result, outbreaks of vector-borne diseases cholera, typhoid fever, and diarrheal illnesses, giardiasis, dysentery, E. coli infection occur frequently. Children and older people are more vulnerable of these diseases. In 2020, 122 million people still used for their daily necessities and about 50% of the world population did not have the opportunity to access adequate sanitation services (WHO & UNICEF, 2021) [17]. Globally, we are still far away from achieving Sustainable Development Goal 6, which is about having access to clean water and sanitation (Mustafa *et al*., 2022) [15]. Poor sanitation, hygiene, and less access to drinking water are the contributing factors of 1.4 million deaths every year occurring mostly in low or middle incomes countries (WHO, 2023) [18]. Bangladesh is called a land of rivers crisscrossed by numerous rivers and water bodies. Though the country has plenty of rivers, it is facing the challenge of providing safe and potable water to its growing population. With a population of about 169,828,991 people and an area of 147,570 square kilometers, Bangladesh is located in northeastern South Asia (BBS, 2022) [6]. Many people in this country are illiterate. Thus, they lack sufficient knowledge on proper use of water and sanitation, and the effects of pollution on both humans and the environment (Roy & Mohanta, 2017) [16]. Public awareness is most important for achieving SDG 6. Over two thirds of the population of the country still resides in rural areas, although urban population is rising at a rapid rate (BBS, 2022) [6]. In the rural areas of Bangladesh people are less concerned about sanitation and hygiene practices. They don't have proper sanitation status. Sometimes their ignorance nearby proper sanitation practices causes water contamination in a great extent. In Bangladesh, less than fifty percent of residences had the fundamental three elements of WASH facilities (Ahmed *et al*., 2021) [2]. An extreme level of water-related morbidity and death was experienced in the 1960s and 1970s, especially in rural areas, as a result of a number of variables such as poor conditions, an increasing population growth rate, the traditional practice of using open ponds for drinking water, and a lack of proper sanitary procedures (Islam *et al*., 2015) [12]. Muktagacha Upazila is situated at the Mymensingh Division in Bangladesh. With an area of 314.70 square km, Muktagacha has 96,657 households and total population is 3,66397 people. Population Density is 1300 people per square kilometer which denotes a densely populated area (Wikipedia, 2024). Less awareness, inadequate sanitation system results in a serious unhygienic condition in many areas in Muktagacha Municipality. The objectives of the research in the areas are- (i) to evaluate the water quality parameters like DO, p^H, EC, TDS, Total Coliform, and Fecal Coliform from different drinking water sources, and (ii) to evaluate the hygiene practice status of people in Muktagacha Municipality.

Materials and methods

1. Study area

Muktagacha Upazila is located in the north central region of Bangladesh. It is bordered to the northwest by Jamalpur Sadar Upazila in the Jamalpur District, to the northeast by Mymensingh Sadar Upazila, to the south by Fulbaria Upazila, and to the west by Madhupur Upazila in the Tangail District. There are 9 Unions and 1 Municipality in Muktagacha Upazila. Muktagacha Municipality is selected for our study area. The size of the city is 7.28 km^2 and also consists of 9 Wards.

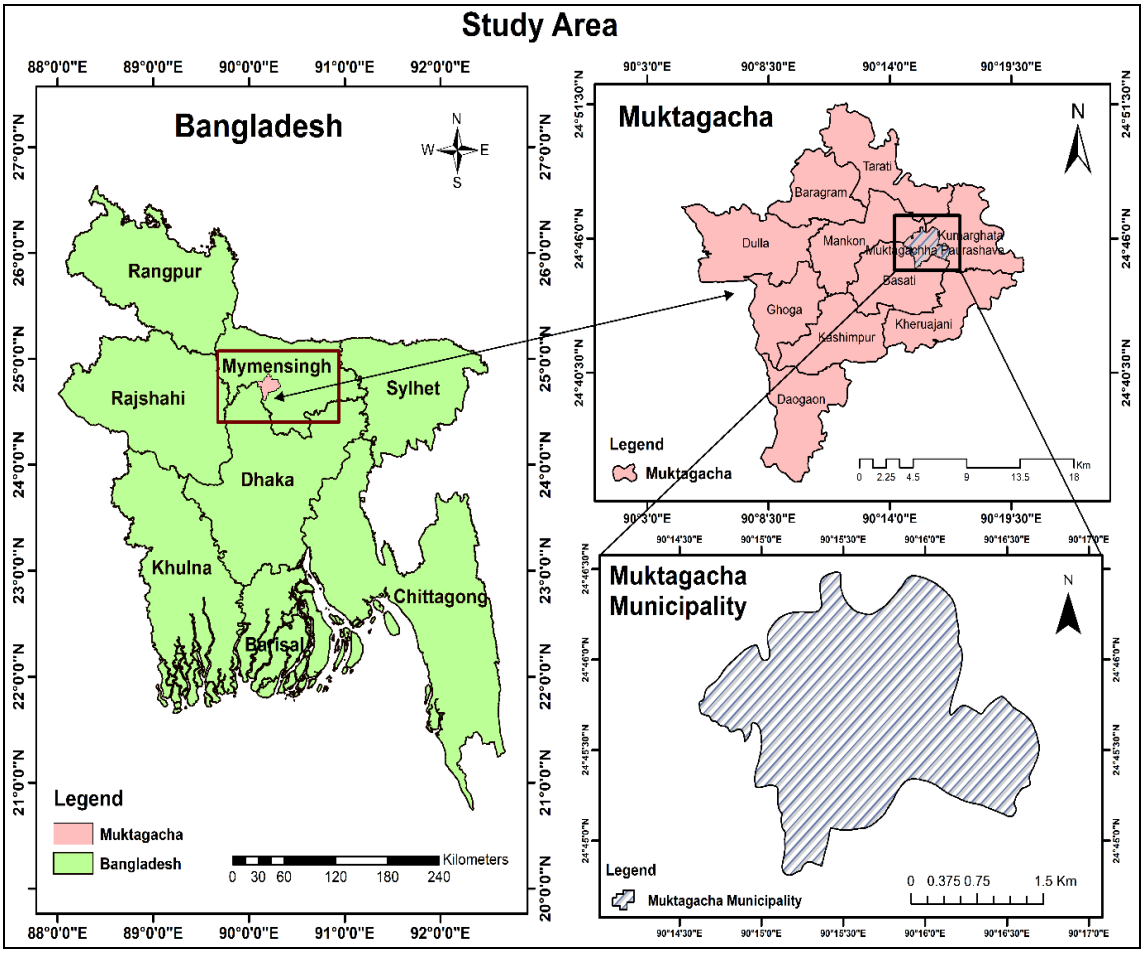

Fig 1: Location map of study area (Muktagacha Municipality, Mymensingh)

2. Data collection and analysis

The research was conducted in two phases. Firstly, water sample was collected and the drinking water parameter was tested on the spot. Secondly, a survey was conducted by asking selected questionnaires to assess their hygiene practice status.

2.1. Water sample collection and analysis

In total 27 water samples were collected from the submersible pump, tube well and supply water in the 9 Wards in Muktagacha Municipality. 9 water samples from tube well, 4 water samples from supply water, 14 from submersible pump were collected from December 15, 2023 to December 30, 2023. In the portion of sample analysis, A digital Hanna Multi-parameter was used to measure the Temperature, pH, TDS, EC of the water samples. These parameters were tested at the location of sample collection. Selectively 9 samples were collected for the bacteriological test. These 9 samples were immediately transported to the Department of Public Health & Engineering - Laboratory in Mymensingh District and processed within 4 hours for total and fecal coliform testing. Membrane Filtration Method was used to analyze bacteriological analysis. Obtained Data are analyzed by using Microsoft Word and Microsoft Excel to present the result in a tabular form. Besides, for additional processing and analysis to gain more insight of the distribution of the water parameters at various sampling points, the processed data is transferred into the ArcGIS software.

2.2. Survey data collection and analysis

For getting the primary data firstly, a set of questionnaires were prepared to achieve the research goal including closed and open questions. Data was collected through face to face interviews of people during the field survey. Mainly, primary data are used to carry out the research. In total 135 people from 135 families who are closely connected with sanitation and hygiene were interviewed with relevant information. Average 15 families were investigated in each Ward. Data are analyzed by using Microsoft Word and Microsoft Excel to show the result in a tabular form.

Results and discussions

1. Water data analysis

The analysis includes the assessment of p^H, DO, EC, TDS from the collected sample. It includes data from survey on hygiene practice in Muktagacha Municipality.

Table 1: Water Quality Parameters for Water Collected from Different Drinking Water Source in Muktagacha Municipality

Location	Sample ID	Temperature (^{0}C)	pH	EC (µS/cm)	DO (ppm)	TDS (ppm)
Ward -1	S-1	22.33	7.4	270	7.18	135
	S-2	24.42	7.13	257	2.26	128
	S-3	22.96	7.21	239	4.19	119
	Average	23.23667	7.2466	255.3333	4.543333	127.3333
Ward-2	S-4	25.5	6.93	329	4.99	164
	S-5	25.35	6.86	255	2.36	127
	S-6	24.49	6.65	282	3.62	141
	Average	25.113333	6.81333	288.6667	3.656667	144
Ward-3	S-7	24.91	7.1	346	7.67	174
	S- 8	24.75	7.2	299	8.35	151
	S-9	26.19	6.85	525	7.7	263
	Average	25.283333	7.05	390	7.906667	196
Ward -4	S-10	23.99	6.92	324	8.28	162
	S-11	24. 5	7.19	745	9.69	372
	S-12	23.19	6.99	536	8.9	268
	Average	23.59	7.03333	535	8.956667	267.3333
Ward-5	S-13	21.52	6.86	316	1.85	158
	S-14	23.94	6.52	255	3.11	127
	S-15	25.47	6.44	328	1.59	164
	Average	23.64333	6.60667	299.6667	2.183333	149.6667
Ward-6	S-16	23.41	7.02	268	9.61	134
	S-17	23.88	7.07	159	8.88	110
	S-18	24.33	6.95	276	8.12	138
	Average	23.87333	7.0134	234.3333	8.87	127.3333
Ward-7	S-19	24.17	6.81	336	3.79	168
	S-20	23.96	6.77	334	3.28	167
	S-21	23.45	7.19	302	6	151
	Average	23.86	6.9233	324	4.356667	162
Ward-8	S-22	26.02	7.15	302	6.49	151
	S-23	25.44	6.84	219	4.05	109
	S-24	22.93	7.01	268	3.4	134
	Average	24.79667	7	263	4.646667	131.3333
Ward-9	S-25	23.4	7.3	303	9.7	152
	S-26	22.01	7.74	297	6.5	148
	S-27	26.77	7.14	360	7.38	180
	Average	24.06	7.393333	320	7.86	160
Total Average		24.17819	7.00889	323.3333	5.886667	162.7778

1.1. p^H content in water

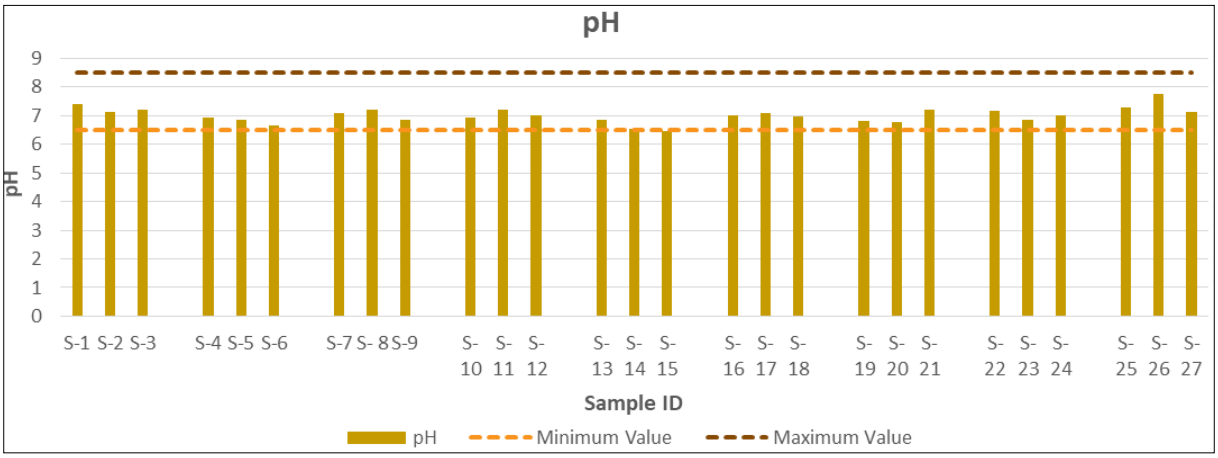

Fig 2: p^H content in water sample

The above graph depicted that highest p^H found at Sample 26 which was 7.74 and the lowest was 6.64 which were at Sample 15. We have seen that the average p^H level high in Ward 9 which was 7.39 and the lowest in the Ward 5 which is 6.6; 6.5- 8.5 is the standard limit of p^H for drinking water, according to Department of Public Health Engineering. The average the Muktagacha Municipality was 7.00 that was in very satisfactory level as drinking water.

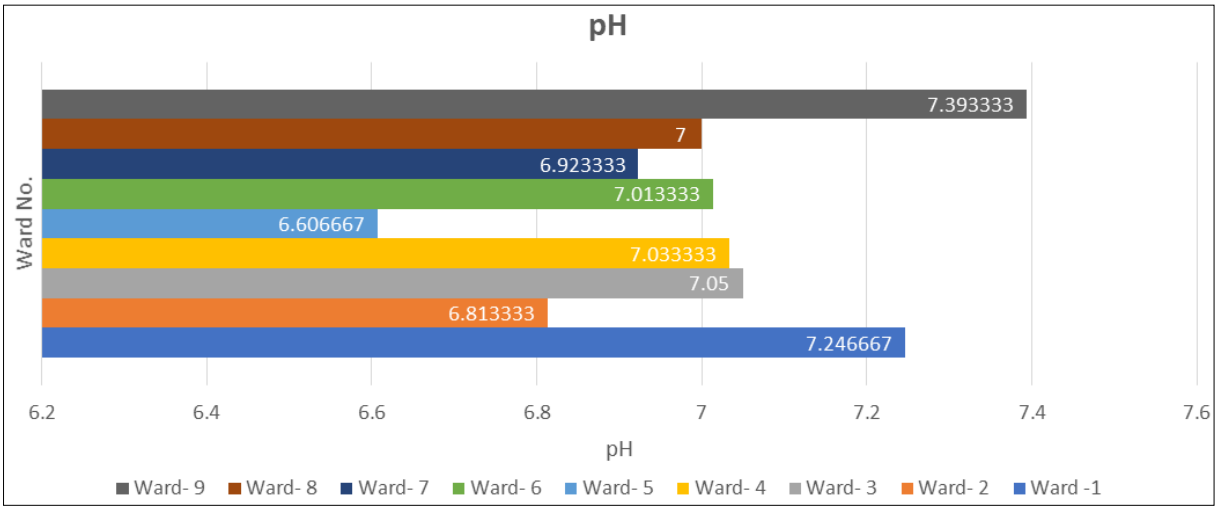

Fig 3: Average p^H content in water sample

1.2. DO content in water

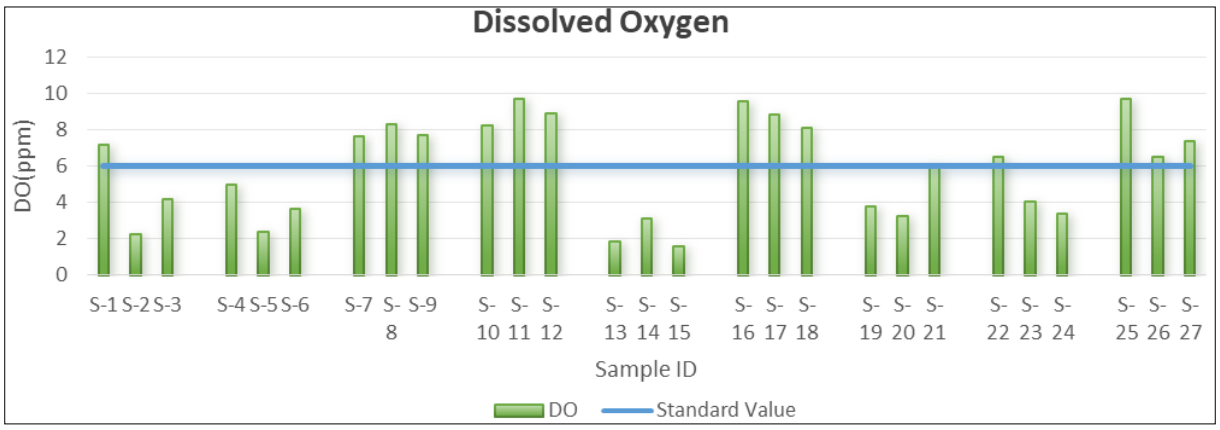

Fig 4: DO content in water sample

According to this study, it has found Dissolved Oxygen ranging from 1.59 ppm to 9.7 ppm in Muktagacha Municipality. The highest DO we found in Sample 25 and the lowest concentration in Sample 15 (Figure 4). But the average DO content was maximum at Ward 4 which was 8.956667 and lowest at Ward 5 which was 2.183333. According to DPHE Standards, DO should be at least 6 ppm in the water. The Sample 2, Sample 3, Sample 4, Sample 5, Sample 6, Sample 13, Sample 14, Sample 15, Sample 19, Sample 20, Sample 23, Sample 24 shows the DO content below 6 ppm. Therefore, it was evident that in many sampling points, the measured DO levels fall below the recommended standards set by DPHE.

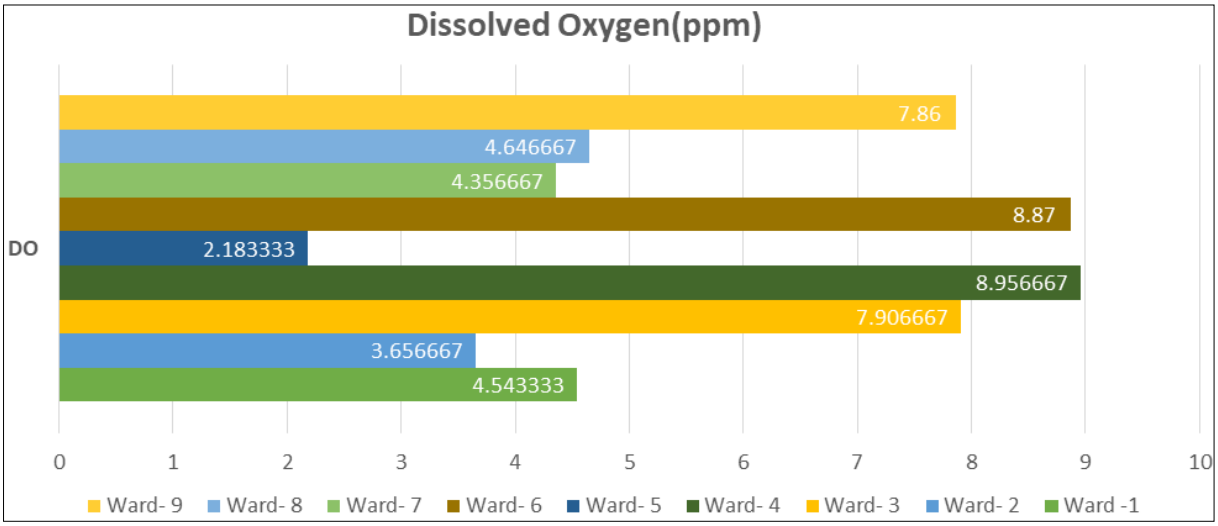

Fig 5: Average DO in water sample

1.3. EC content in water

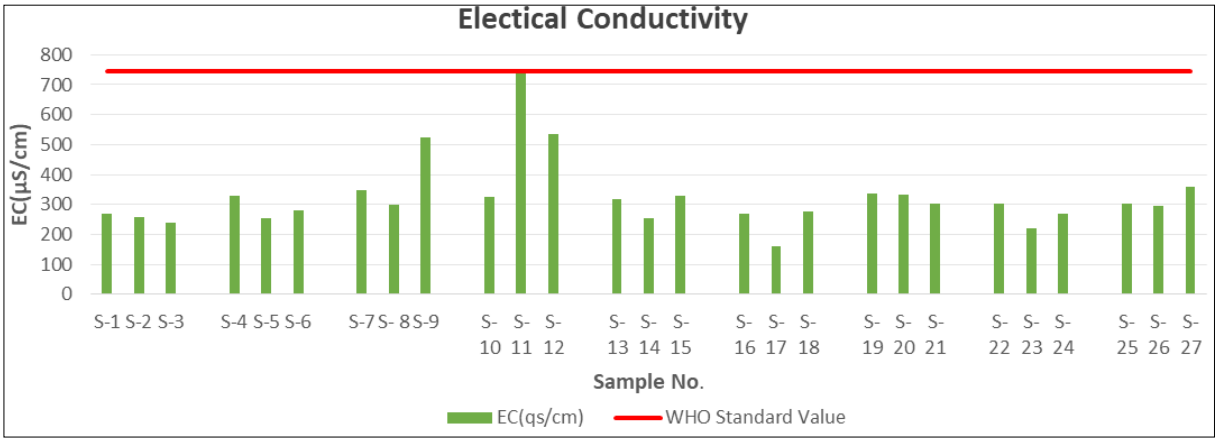

Fig 6: EC concentration in water sample

In Muktagacha Municipality, EC value varies from 745 µS/cm to 159 µS/cm with an average value of 323.33 µS/cm according to this study. As per the WHO guideline, the recommended levels of EC in the drinking water Sample are 750 µS/cm (Mou *et al*., 2023) [14]. In the graph, we have seen the highest EC concentration was found at Sample 11 and the lowest concentration of EC was found at Sample 17. Similarly, the mean highest EC was found in Ward 4 which ws 535 µS/cm and the mean lowest EC is found in Ward 6 which was 234 µS/cm. The EC values found in the study were at quite satisfactory level for drinking purpose.

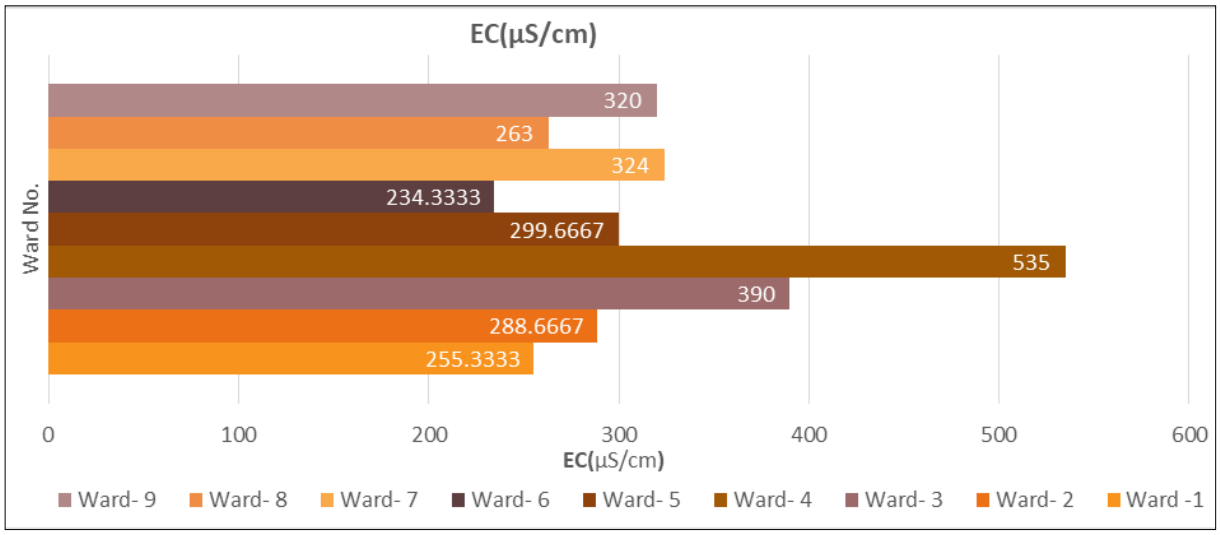

Fig 7: Average EC content in water sample

1.4. TDS content in water

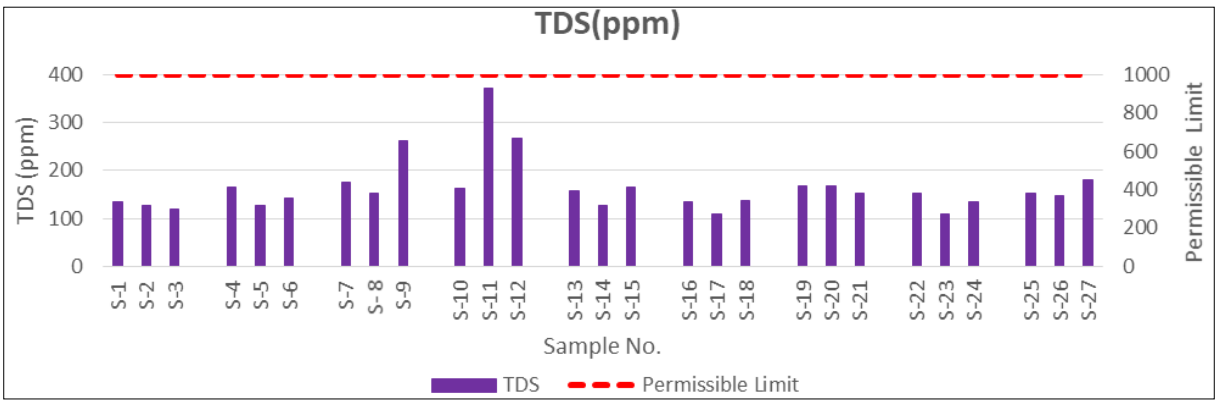

Fig 8: TDS content in water sample

It was observed from the graph (Figure 8) that the TDS levels in Muktagacha Municipality vary between 109 ppm and 372 ppm. The highest recorded TDS concentration was found in Sample 11, while the lowest is observed in Sample

23. However, when considering the average TDS content, it was highest at Ward 4, measuring 267.333 ppm, and lowest at Ward 1 and 6, measuring 127.33 ppm. The recommended TDS concentration for drinking water quality should not exceed 1000 ppm (DPHE, 2023) [8]. Among the Samples analyzed, TDS concentration at all samples is suitable for drinking.

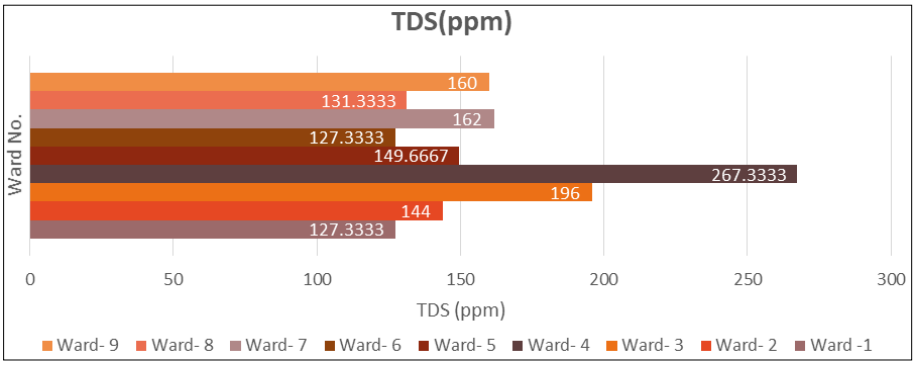

Fig 9: Average TDS content in water sample

1.5. Spatial distribution of pH, DO, EC, TDS

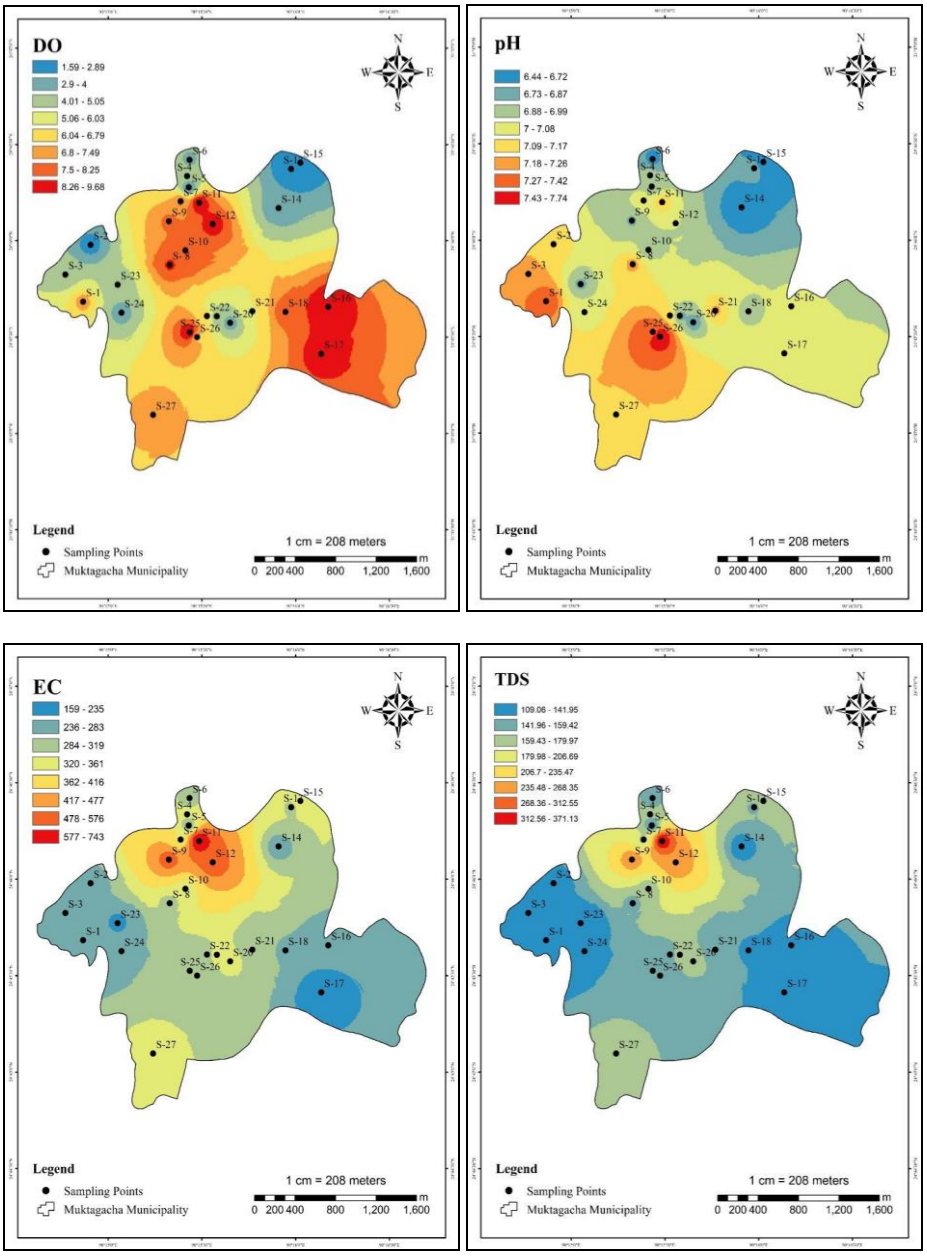

Fig 10: Spatial distribution of p^{H}, DO, EC, TDS

The spatial map depicted the spatial distribution of p^H, DO, TDS, EC concentrations in the Muktagacha Municipality Area. There are small black points scattered around the map indicating the sampling points. Darker red indicate greater pH concentrations and is slightly basic, whereas blue colors reflect lower p^H concentrations. The maximum pH concentrations were recorded at Sample 27 in Ward 9. In the Figure 11b the lower DO concentrations are denoted by blue colors and higher DO Values were denoted by red colors. The maximum p^H concentration was recorded in Sample 11 in Ward 4 and the lowest concentration at Sample 17 in Ward 6. Again in the figure darker blues indicate lower EC concentrations and red colors reflect greater EC concentrations. In the case of TDS we found an almost similar pattern as EC, where the TDS is high EC is also high there. The maximum pH concentration were recorded at Sample 11 in Ward 4, indicated by dark red color and the lowest concentration at Sample 23 in Ward 9 indicated by blue color.

1.6. Total & fecal coliform count in water

Among the 27 samples, 9 selected water samples from 9 Wards were tested for Total Coliform Count and Fecal Coliform Count.

Table 2: Total & fecal coliform count in water samples

Ward No.	Sample No.	Latitude	Longitude	Drinking Water Source	Total Coliform (CFU/100ml)	Fecal Coliform (CFU/100ml)
Ward-1	S-1	24.76139	90.24778	Tube Well	0	0
Ward-2	S-4	24.772263	90.25702	Tube Well	0	0
Ward-3	S-7	24.77009	90.25645	Submersible Pump	14	0
Ward-4	S-10	24.76583	90.25687	Supply Water	52	0
Ward-5	S-13	24.77288,	90.26627	Tube well	0	0
Ward-6	S-18	24.76052	90.26577	Submersible Pump	110	0
Ward-7	S-19	24.76014	90.25966	Submersible Pump	140	0
Ward-8	S-22	24.76016	90.25879	Supply Water	12	10
Ward-9	S-25	24.75875	90.25726	Submersible Pump	0	0

From the table we have seen, 3 water samples from taken from tube well, 2 from supply water and 4 from submersible pump using as drinking water source. The tap water line connected with submersible pump for water supply. According to DPHE, the drinking water standard for Total Coliform bacteria was less than 1 colony-forming unit (CFU) per 100 milliliters (mL) of water and same for the Fecal Coliform. From the Table, we have seen that TC was higher than its standards at Sample 7, Sample 10, Sample 18, Sample 19, Sample 22 among the 10 Samples, in Ward 3, Ward 4, Ward 6, Ward 7, Ward 8 respectively. Again, Sample 22 was contaminated by Fecal Coliform. Any amount of Fecal Coliform in a drinking water sample was an important safety concern and indicates feces were contaminating the water. From the data shown that the frequency of having Total Coliform in water Sample was mostly found in supply water. Only 2 Samples taken from supply water and 2 are found contaminated and 3 Samples from submersible pump are found contaminated. These types of water should not be consumed, not safe for health. No water Sample from tube well was found bacteriologically contaminated. A common thing was that all the submersible pump users and supply water users have water tanks to reserve the water for different applications. From the result of bacteriological test, it can be assumed that the source to Total Coliform can be the water pipes through which it was transmitted and it can also be the water tanks which were not cleaned up regularly.

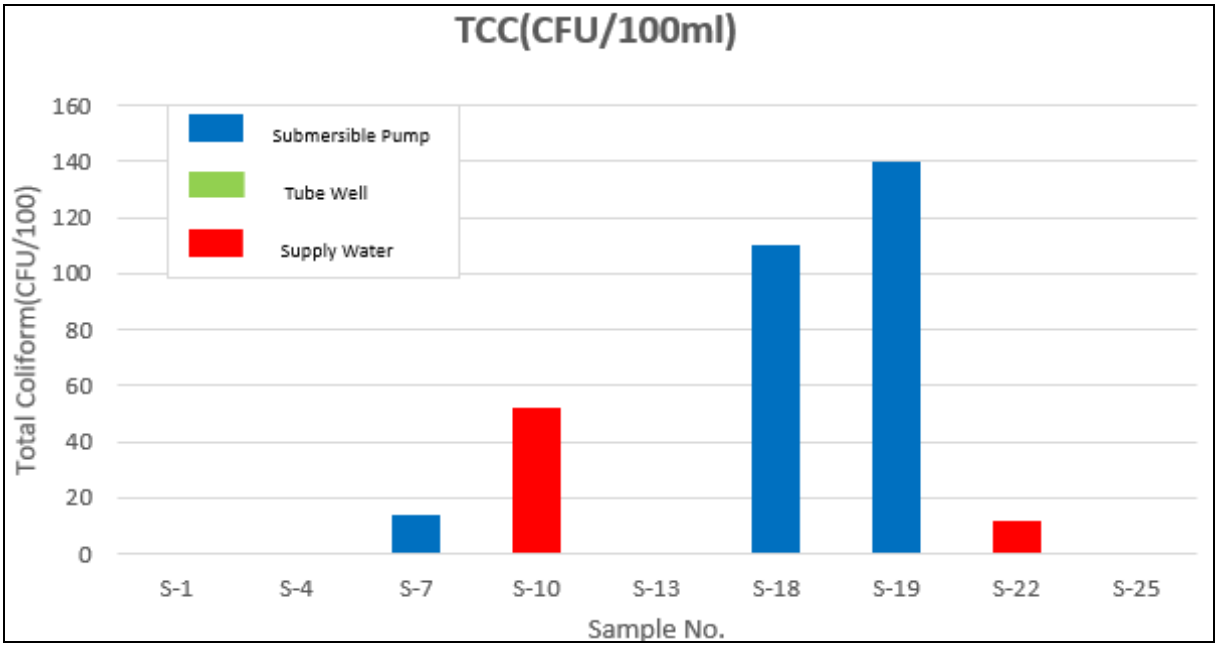

Fig 11: Total coliform count in water

2. Survey data analysis

In this portion, the data obtained from the survey for assessing the hygiene condition of Muktagacha Municipality is shown.

2.1. Information of respondents

In this survey, 73% of the respondents were women and 27% were male, as women are more connected with water collection and more responsive to contribute to the survey, women are prioritized to be respondents. A maximum of 42.20% of the respondents were in the age range of 20–30 years old. About 25.30% of the population was in the 30–40 age range, while 25.50% was in the 40–50 age range. 6% of the respondents were younger than 20.

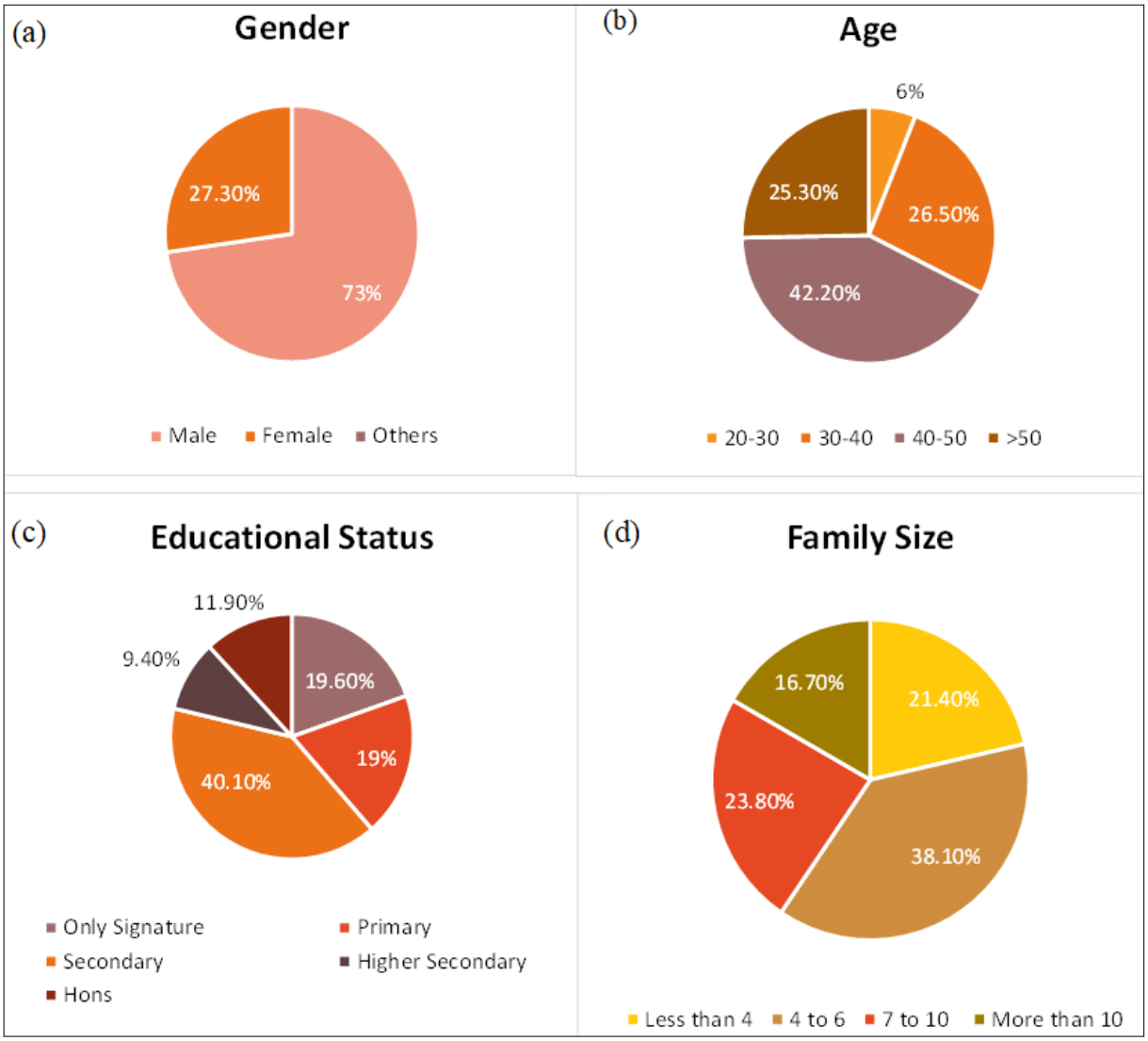

Fig 12: Information of respondents

Figure shown the several categories of educational status: only signature, primary, secondary, higher secondary, and graduate. Of the respondents, about 11.90% can only sign, 19% only completed primary school, 40.10% completed secondary school, 9.40% completed higher secondary and 11.9% are graduates. In this survey, 38.1% of respondents said they belonged to families with 4 to 10 members, while 23.8% reported they belonged to families with 6 to 10 members. Furthermore, 21.4% of respondents said that there were fewer than 3 people in their families and 16.7% of respondents stated that their families consist of more than 10 members.

2.2. Access to drinking water

The information displayed in the bar chart shown how different water sources were used among the several Wards of the Muktagacha Municipality. In Ward 8, and Ward 9, the largest percentage of households (80%) use submersible pumps to meet their drinking purpose, whereas Ward 3, Ward 4, Ward 6, Ward 7 have the second-highest rate (73.3%). A significant proportion of the people in Ward No. 5, Ward No. 1 and Ward No. 2 (66.667%) also consume their water primarily via submersible pumps. Another source of drinking water for many households was a tube well. From the graph, we have seen that almost 26.7% people use tube wells in Ward 5, the highest tube well consumer. 20% of families in Ward 1, Ward 2, and Ward 7 use tube wells, which was the second largest. In Ward 3, Ward 4, Ward 6 and Ward 9, 13.33% people consume drinking water from tube wells. Only 6.7% of households use tube wells in Ward No. 8, which was the lowest percentage compared to other Wards. Some people also use supply water as drinking water source. But the overall percentage of supply water using is very low. The highest

percentage of supply water consumers was 13.333% and the lowest percentage is 6.667% in Ward No. 5, Ward No. 7 and Ward No. 9. We also found that people did not have adequate supply water in these areas. However, in many families, people have supply water connection but were not fully dependent on it. In total, about 72.59% of people rely on submersible pumps, whereas 16.3% of people use tube wells, and only 11.11% of people rely on supply water.

2.3. Types of toilets

The survey shown that 83.40% toilets were water sealed and these types of toilets was typically denoting a good hygiene condition but 14.60% of toilets were not water sealed and 2% of households have direct disposal line to sewer line connected with their latrine. We have seen that the distance between toilet and water source is less than 10m in 33.3% of households and 10-20 m in 42.9% of households, 20-30m in 11.9% and greater than 30 m in 11.9% households in Muktagacha Municipality. The distance below 10 m has a greater risk of fecal contamination in the water source.

Recommendations and conclusions

1. Recommendations

Based on this research findings of bacteriological problems and inadequate sanitation/waste management in Muktagacha Municipality here are some recommendations to improve drinking water quality and hygiene practices in the Muktagacha Municipality area:

Improved water treatment at household level: The water sources are susceptible for bacteriological contamination has to be treated before drinking. Promoting Boiling Filtration I can be the simple and affordable domestic solution for removing pathogen.

Construction of sanitary toilets: In some area people are unable to install good sanitation facilities for their economic instability. Local government should allocate a budget for them to provide a good sanitation system. Some people are wealthy enough but have lack of awareness and they are overlooking the importance of maintaining proper sanitation. Advocate for the construction of proper sanitary toilets with proper waste management to prevent fecal contamination of water sources.

Regular cleaning up toilets and water tank: Without regular cleaning up, toilet conditions can be very much unhygienic. People who clean their toilets after this prolonged duration use it are at a higher risk of contracting water-borne illnesses. It should be cleaned up regularly. Again, cleaning water tank regularly is very important to keep water safe.

Improve waste management system: In Muktagacha Municipality, there are lacks of adequate waste management systems. Proper waste management, more dustbin installment, more drainage systems, their maintenance have to be implemented.

Hand washing campaigns & hygiene education: Organize workshops and awareness campaigns on topics like safe water handling, sanitation maintenance, disposal of waste, etc. to improve community hygiene practices generally.

Community involvement: Engage people from the community in the implementation of the suggestions. This will ensure the long-term success and develop a sense of ownership.

Conclusions

Safe adequate water supply and proper hygiene practice were co-related with each other. From the survey, we found that average physic-chemical parameters showing satisfactory level but in the bacteriological analysis, we found 50% of the samples were contaminated according to the study. The probable cause of the bacteriological contamination can be inadequate sanitation and proper waste management practices. A significant number of people are habitable with improper waste management and insufficient sanitation system in Muktgacha Municipality. Poverty and illiteracy are the one of the major issues. A few NGOs have started attempting to raise awareness. But initiative from local government to main a safe hygiene status is not enough. Organizing workshops and awareness campaigns on topics like safe water handling, sanitation maintenance, disposal of waste, etc. to improve community hygiene practices generally. Both Government and Non-government organization should work together and take additional measures to increase the awareness about proper sanitation and hygiene practice status in Muktagacha Municipality.

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Disclosure statement

Conflict of interest: The authors declare that there are no conflicts of interest.

Compliance with ethical standards: This article does not contain any studies involving human or animal subjects.

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