Study of water quality index to determine the quality of tanker water in a rural area of Bangalore & survey for WASH practices

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ABSTRACT
The Water Quality Index (WQI) of tanker water supplied in kudlu area of Bangalore was studied for a period of 18 months. This studied area is heavily dependent on water supplied by tankers that claim to be of drinking water quality. The results indicated poor water quality in the supplied area. Further, A community-based survey was conducted among the residents of the area via an e-questionnaire using interview method. The physico chemical and microbiological characteristics was studied for the supplied water samples. Data was collected from 368 respondents and the results analysed using SPSS (Statistical Package of Social Science) software version 20. A direct correlation ($p<0.005$) was established between the economic condition of the respondents and their hygiene practices. Economically poor people seemed to be unaware of the need for water treatment before consumption, adequate hand washing practices and basic sanitation guidelines. This leads to a greater number of incidences of water borne diseases among this sector of the society.

Keywords:drinking water, hygiene, Kudlu, sanitation, tankers, washing, Water Quality Index.

INTRODUCTION
Water is essential for the sustaining of life and other required activities like agriculture, industry, drinking, hygiene and sanitation. As per WHO and UNICEF in 2020, 65% of population in developing countries lacked proper sanitation, 73% lacked hygiene and 35% lacked access to basic water. [1]
More than 850 million and 2.5 billion people in the World have limited access to clean water and sanitation respectively as per 2013 data. This leads to an increase in the mortality cases due to diarrhoea which is a waterborne disease. As per the World Health statistics, fatalities due to diarrhoea occur most in India with more than 3,86,000 deaths. [2]
Living in a healthy environment along with sanitation are essential for community wellbeing. The Indian Government is providing funds to build new latrines, maintain old latrines, waste recycle bins and dustbins under the Swachh Bharat mission. Effort is also being made to make the people residing in slums aware about cleanliness and sanitation under the Nirmal Bharat Abhiyan scheme in 2018. [3]
Poverty in developing countries like India gives rise to compromised water and food quality, sanitation and environment as of 2009. [4]
Water, Sanitation, and Hygiene (WASH) practices are known to affect the status of growth and nutrition in people. As per Multidimensional poverty of India, approximately 46% of the Indian population live in severe poverty as per 2019 data. [5]
Conditions and practices which maintain good health and prevent the spread of diseases is the meaning of hygiene. Adequate personal hygiene maintenance reflects the quality of a healthy environment. [6]

Literature Review
Prior studies have been conducted in other areas of India to understand the sanitation and hygiene knowledge. Literature references published within the last one decade has been reviewed and included to make this research current and up to date.
Kuberan et al (2015) conducted a study in Thandalam village in Chennai to know the attitude, knowledge and practices related to sanitation and drinking water. 45% of the studied population were not treating the water supplied before usage and 50% of the people felt that the supplied water was clean and did not require any

treatment before usage. 25% of them did not have toilet facility at their homes. [7]

Ravi Pachori (2016) conducted a community-based study in Salem district of Tamil Nadu, India to understand the drinking water, hygiene and sanitation practices of the residents. 96.3% of the individuals covered drinking water, 61.7% practiced covering of dustbins, 83% used sanitary toilet and 94% practiced handwashing after toilet use. The studied households seemed to have knowledge regarding basic sanitary and hygiene practices like washing hands after toilet, use of sanitary toilet and covered dustbin. They also practised consumption of safe and clean drinking water. [8]

Reshma et al (2016) conducted a descriptive study among the women in villages of Manipal of Udupi district to assess the practice and knowledge about hygiene, sanitation and water. Out of the 300 respondents, 40% had good knowledge, 42% had average and 18% had poor knowledge about water, hygiene and sanitation. 68.3% of them had proper ventilated toilets and 83.7% cleaned water storage vessel regularly. The results of the study concluded that most of the participants had average knowledge regarding hygiene and sanitation; however, many of them practiced inadequate hand washing and unsafe water, sanitation and hygiene practices. [9]

Kumar Karn et al (2014) conducted a survey on water supply, sanitation and its associated health impacts on slums, pavement dwellers and squatter areas of the Mumbai city. The results of the field study showed very low water consumption, lack of sewerage and improper excreta disposal. 30% of deaths were accounted for water borne diseases. The annual number of diarrhoea, typhoid and malaria related cases were 614, 68 and 126 every thousand population respectively. [10]

Patel et al (2020) studied the WASH practices among the urban residents of India where the crisis of water supply and demand was reported before. 95% (95% CI, 0.98, 1.17) of the studied households had access to proper drinking water sources, 77% had water source within their reach, 90% had proper latrine facilities (95%CI, 1.17, 1.33), 52% (95% CI, 1.08, 1.19) had garbage collection facility under the municipal corporation and 60% had drainage connections (95% CI, 0.84, 0.99). However, 97% (95%, CI, 1.75, 2.39) had problems associated with mosquitoes and flies. [11]

Bauza et al (2021) conducted telephonic interviews with household residents of Orissa district in India to understand the WASH practices during the COVID-19 pandemic. Majority of the participants (86%) reported an increase in the number of handwashing times, thorough washing using soap and water. 48% and 41% reported cleaning of village tanks and house cleaning being conducted respectively. However, change in latrine usage was minimal during the pandemic. [12]

Chattopadhyay et al (2019) conducted a cross-sectional study in the Indian states of Chhattisgarh, Bihar and Orissa to understand the WASH practices of adolescent girls. 82% of the studied population practiced open defaecation and 76% did not use sanitary pads. 17% were thin and 1/3 of them were stunted. Hence, poor menstrual hygiene and sanitation was associated with poor nutritional status among the adolescent girls. [13]

The physicochemical and microbiological characteristics of random tanker water samples was studied in 2019. The results showed that the physicochemical parameters turbidity, total hardness, conductivity, dissolved oxygen, nitrate, chloride and calcium were within the acceptable limits for most of the collected tanker water samples. However, total coliform was more for some of the collected samples. [14]

Water samples from Sankey tank and Maratahalli lake in Bangalore was studied for a period of three months in 2012 between March and May. Cations like iron, calcium, magnesium, sodium, potassium and anions like sulphate, nitrate, phosphate, chloride, bicarbonate and fluoride were studied apart from the conventional physicochemical parameters like pH, conductivity, total hardness, Total dissolved solids (TDS), dissolved oxygen, turbidity and colour. From the calculated WQI, it was observed that the tanker water in Sankey was found to be good, however, the lake water of Maratahalli was poor. [15]

Health Hazards of water contamination and importance of WQI

Conversion and integration of complex datasets of physico-hydrochemistry elements with hydrogeological parameters that have reasonable effect on the quality of groundwater into qualitative and quantitative water quality data is the goal for calculating the WQI. This helps to understand and enhance the evaluation of quality of water. A series of calculations for converting several physicochemical values into a single value that reflects the quality of water and suitability for drinking is the motive for calculating this index. [18]

The acidity and alkalinity of a solution is measured by pH. The metabolism of aquatic organisms is dependent on the temperature of water. Stress in aquatic system is observed due to high temperature of water that reduces the ability of water to hold oxygen and other gases. The total of magnesium and calcium concentration in water is called hardness. Arsenic is present in many areas of the world like China and India. The Indian state West Bengal has been reported to contain Arsenic in water. Toxicities like vomiting, pain in abdomen and muscles and skin flushing occurs due to acute intoxication. Dermatological complications, neuropathy and peripheral vascular diseases occur due to chronic intoxication. Toxicities like anemia and damage to reproductive system occur due to lead intoxication. [25]

Study Area

The study area is a village in the eastern City of Bangalore called Kudlu having the coordinates 12.8910° N, 77.6400° E. Although this area has a mixed population, most people are economically poor, which is still under development. The water crisis is prevalent throughout the year in this semi-urban zone, and the residents are dependent on water supplied through tankers whose quality requires a comprehensive study. Very few residential blocks bear boreholes and depend on groundwater which is recharged periodically by the water supplied by the tankers. Economically weaker sections receive water supply through tankers once in two weeks or at times once every month.

Prior testing of the supplied tanker water in this area has not been conducted before. There is no monitoring station to test the quality of water supplied in Kudlu. Further, there exists no seasonal data on the water quality of this zone. A seasonal collection of the water from the tankers, households (apartments and homes of poor), their comprehensive physicochemical analysis, analysis of select inorganic metal contaminants, screening for any waterborne disease-causing microorganism, can help us comment on the quality of water supplied in the area by the tankers.

The tankers claim to supply drinking water in the area. The quality of the water should be tested to understand and conclude if the supplied water is of drinkable quality.

MATERIALS AND METHODS

Water samples were collected from 04 tanker water suppliers in Kudlu area of Bangalore. 01 sample collected from RO water purifier served as the control. Samples were collected for a period of 18 months from September 2022 to February 2023.

pH, electrical conductivity, temperature was measured using a portable meter. Water testing strips were used to measure the other parameters like alkalinity, hardness, chlorine, cyanuric acid.

The collected water samples were sent to Fogiene laboratory for testing the metals like calcium, magnesium, iron, copper, lead, zinc and arsenic. APHA method was used to detect the presence of magnesium. Indian standard 3025 (Part 40 and 53) was used to test Calcium and Iron respectively. Indian standard 3025 (Part 2) was used for the heavy metal characterization. Membrane filtration method was used to detect the presence of E.coli bacteria.

WQI was calculated using 16 parameters i.e. Chlorine, pH, alkalinity, cyanuric acid, total hardness, conductivity, temperature, TDS, calcium, magnesium, heavy metals iron, zinc, lead, arsenic, copper and cadmium for all the collected samples.

There was no missing data and results have been accurately presented in this research article.

The Indian standard specified for drinking water was used for calculating the WQI. [19]

Firstly, each of the 18 parameters was assigned a weight (wi) based on its relative importance on the overall drinking water quality (Table 1). The maximum weight 5 was assigned to Arsenic, cadmium, lead and E.coli due to its major importance in determining the quality of water. The minimum weight 1 was assigned to sodium, potassium, iron, magnesium, potassium, zinc and copper due to its comparatively insignificant role. The other parameters like pH, total hardness, TDS, chloride, Calcium, conductivity, temperature, cyanuric acid and alkalinity were assigned weights within the range of 1 to 5 depending on their relative significance in the evaluation of water quality. Secondly, the relative weight (Wi) of the chemical parameter was calculated using the following equation:

Wi = wi/ ∑i=1∑wi
Where, Wi= relative weight,
wi= weight of every parameter and
n= number of parameters

Table 1. Relative weight of chemical parameters

Parameters	Indian Standard	Weight (Wi)	Relative weight (Wi)
Calcium (mg/l)	75	3	0.06
Iron (mg/l)	0.3	1	0.02
Magnesium (mg/l)	30	1	0.02
Sodium (mg/l)	NA	1	0.02
Potassium (mg/l)	NA	1	0.02
Zinc (mg/l)	5	1	0.02
Lead (mg/l)	0.01	5	0.1
Arsenic (mg/l)	0.01	5	0.1
Copper (mg/l)	0.05	1	0.02
Cadmium (mg/l)	0.003	5	0.1
E.coli (MPN/100ml)	Not Detected	5	0.1
Total chlorine (ppm)	0.2	1	0.02
Cl/Br (ppm)	0.2	1	0.02
pH	7.5	2	0.04
Alkalinity (ppm)	200	1	0.02
Cyanuric Acid (ppm)	50	1	0.02
Total hardness	200	5	0.1
Conductivity (micro s/cm)	400	3	0.06
Temperature (degree celcius)	10	2	0.04
TDS	500	5	0.1

∑Wi=50

The calculated relative weight (Wi) is presented above in Table 1. Thirdly, the quality rating scale (qi) for every parameter was calculated by dividing the concentration in each water sample by the respective Indian standard, and the result was multiplied by 100.
Qi = Ci/Si X 100
Where, qi= rating quality,
Ci = concentration of every parameter in each water ample in mg/L,
Si = Indian water standard for drinking water for every parameter in mg/L.
For calculating the WQI, the sub index (SI0 was determined for every chemical parameter, as represented below:
SIi = Wi X qi
WQI = SI_{i-n}
Where, SIi = sub index of ith parameter,
Wi = relative weight of ith parameter,
Qi = rating based on concentration of ith parameter and
N = number of parameters. [20]
The calculated WQI may be classified into the following types:
WQI<50: excellent water
Within 50 to 100 WQI: good water

Within 100 to 200 WQI: poor water
Within 200 to 300 WQI: very poor water
WQI>300: not fit for drinking [15]
An online questionnaire prepared on popular e-format (Google forms) was circulated among the apartment dwellers of Kudlu. The data was collected between the months of March and April of the year 2022. Reminders on social media was sent weekly in order to obtain the maximum responses. Responses of poor people residing in underdeveloped homes were recorded in a tabloid phone in the forms via an interview method. Language was a barrier during collection of responses as most of the poor people did not understand the usage of Google form. The help of a local person knowing the native languages prevalent in the area like kannada, tamil and telugu was obtained in order to smoothly communicate with the uneducated people. A total of 1050 people were distributed with the e-survey questionnaire which included both the apartment residents and poor people (responses obtained by interview method) which ensured a rational distribution between the gender to get the responses. All the collected responses were subjected to the SPSS analysis. There were no missing data. None of the responses were omitted and questions were asked in a non-leading manner in order to prevent bias. The detailed methodology is described in below flow diagram (Figure 3). No ethical approval was required since voluntary responses were obtained from the responders.
People of ages 20 and above of both the genders participated in this survey as they had access to smart phones to provide their responses in an electronic format. Children and adolescents were excluded from this survey. Responses from illiterate people were gathered via an interview and responses filled in the Google form.
The first part of the questionnaire contained questions relating to gender and age group, while the second part of the questionnaire contained questions related to awareness about hygiene, sanitation and wash practices.
A total of 368 responses were gathered via the e-questionnaire circulated and interview conducted with the poor people. The responses were analysed using Statistical Package for Social Sciences (SPSS) software version 20. Descriptive statistics were performed to calculate the frequency and percentage. A Chi-square analysis was conducted to identify the variation in the awareness toward water, hygiene and sanitation and socio-economic status of the people. Handwashing practices, storage of water used and cleaning of vessels used for storage, water treatment before consumption and diseases caused by water borne infections were the variables considered.

RESULTS AND DISCUSSION

Table.1 Demographic characteristics of the respondents

Characteristics	Variable	Frequency (% of recorded response)	Chi square (df and p-value)
Gender	Male	57.88	
	Female	42.11	
Age group	20-30	19.56	
	31-40	41.57	
	41-50	23.09	
	51-60	7.60	
	> 60	8.15	
Marital status	Single	12.5	
	Married	87.5	
Number of members in family	Less than 4	45.7	23.496 (6, 0.001)
	4-6 members	36.4	
	6-8 members	7.9	
	> 8 members	10.1	
Number of years staying in the area	1-3 years	9.84	
	3-5 years	33.15	
	5-10 years	35.32	

	> 10 years	21.19
	Poor	49.2
	Rich	32.3
	Average	18.5

Table 2. Socio-economic characteristics of the respondents

Characteristics	Variable	Frequency (% of recorded response)	Chi square (df and p-value)
Qualification	Graduate	17.9	291.844 (6, 0.000)
	High school	3.3	
	Intermediate	49.7	
	Post graduate and above	29.1	
Socio-economic condition (as per response obtained from respondents)	Average	18.5	
	Poor	49.2	
	Rich	32.3	
Financial condition (as per response obtained from respondents)	Average	18.5	
	Poor	49.2	
	Rich	32.3	
	Average	18.5	
Occupation	Domestic help	19.8	261.895 (8, 0.000)
	Labourer	15.8	
	Student	6.0	
	Unemployed	19.0	
	Working in office	39.4	

Table 3. Hygiene and Sanitation practices among the respondents

Parameters	Response statement	Frequency (% Of responses)	Chi square (df, p-value)
Having toilet at home	No	5.7	23.009 (2, 0.000)
	Yes	94.3	
Type of toilet	Common	60.3	
	Personal	35.1	
	Not Applicable	4.7	
Number of toilets	One	47.4	
	Two	34.8	
	Three	13.2	
	None	4.6	
Practising washing hands before meals	No	38.0	74.987 (2, 0.000)
	Yes	62.0	
Number of times of washing hands in a day	Less than 5 times	30.8	
	5-10 times	57.2	
	10-15 times	9.5	
	15-20 times	1.5	
	More than 20 times	1	
Purpose of water use	Drinking	6.0	213.799 (6, 0.000)
	Washing clothes and Utensils	1.1	

	Drinking, washing and toilet use	39.4
	Washing and toilet use	53.5
Wearing mask if standing in long queues for collecting water	Yes	21.5
	No	28.1
	Not Applicable	50.4
Amount of water consumption	Less than 10 litres	11.4
	10-50 litres	63.8
	50-100 litres	22.9
	More than 100 litres	0

Table 4. Knowledge about water and usage

Parameters	**Response statement**	**Frequency (% Of responses)**	**Chi square (df, p-value)**
Storage vessel of collected water	Pots/utensils	69.5	
	don't collect	25.3	
	drums	5.2	
Period of storage of water	1 day	8.4	
	2 days	8	
	3-4 days	45.5	
	More than 1 week	38.1	
Frequency of cleaning storage vessel	Daily	5.6	
	Weekly	51.8	
	Monthly	32.2	
	Ever 3-6 months	10.4	
Source of water	Borewell	9	
	Motor	8.8	
	Tankers	82.2	
Boiling or filtering of water before consumption	No	60.0	145.462 (2, 0.000)
	Yes	39.4	
Having water filter at home	No	63.0	202.724 (2, 0.000)
	Yes	37.0	
Water treatment by chlorination	No	72.0	130.291 (2, 0.000)
	Yes	28.0	
Frequency of chlorination	Daily	0	
	Weekly	1.5	
	Monthly	17.5	
	Every 3-6 months	10	
	Not Applicable	71	

Table 5. Prevalence of water borne diseases among the Residents

Parameters	Response statement	Frequency (% Of responses)	Chi square (df, p-value)
Suffering from water borne diseases	Diarrhoea	4.8	67.730 (28, 0.000)
	Hair falls	4.3	
	Joint pains	8.8	
	Skin rashes	5.2	
	Stomach pain	12.0	
	Yellowing of skin and eyes	4.0	
	None of them	60.9	
Amount spent to treat the diseases	Less than 1000	7.3	84.868 (8, 0.000)
	1000-5000	18.2	
	5000-10000	15.8	
	> 1000	2.4	
	Need not spend for the diseases	56.3	

The results for the WQI obtained per month for all the samples is presented below in Table 6:

Table 6. Monthly WQI for samples

Months	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
September-21	121.19	117.54	113.91	116	27.95
October-21	95.04	115.37	91.87	92.70	30.32
November-21	73.54	112.18	134.52	63.69	29.4
December-22	92.65	81.58	78.05	91.48	17.67
January-22	87.84	83.92	88.8	79.06	20.5
February-22	90.25	117.66	132.72	123.8	19.08
March-22	85.71	130.38	138.38	133.31	38.86
Aprtil-22	142.49	157.4	149.1	115.58	29.2
May-22	50.61	84.45	61.52	53.21	22.39
June-22	108.76	132.09	87.114	79.93	28.05
July-22	65.197	106.57	131.4	75.38	54.7
August-22	132.18	128.27	146.12	111.7	31.77
September-22	43.923	81.02	107.4	74.28	36.39
October-22	82.29	122.49	102.81	80.41	21.96
November-22	124.35	119.24	129.68	101.18	62.06
December-22	122.22	109.6	81.689	76.39	20.79
January-23	140.41	119.00	71.82	72.64	23.22
February-23	98.97	98.53	156.45	115.87	52.45

The graphical presentation of seasonal variation of tanker water samples and purified water is presented below:

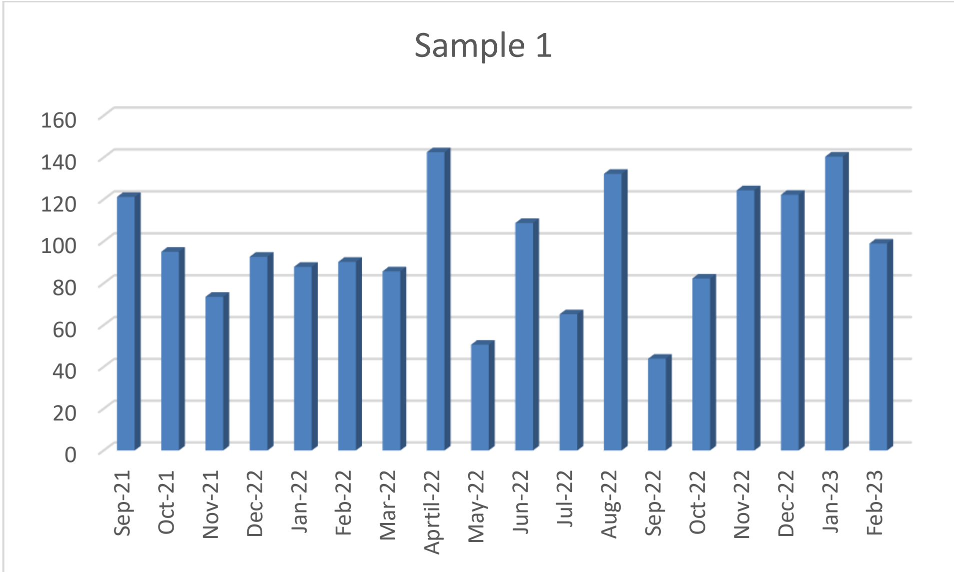

Figure 1. WQI variations for Sample 1 (tanker water)

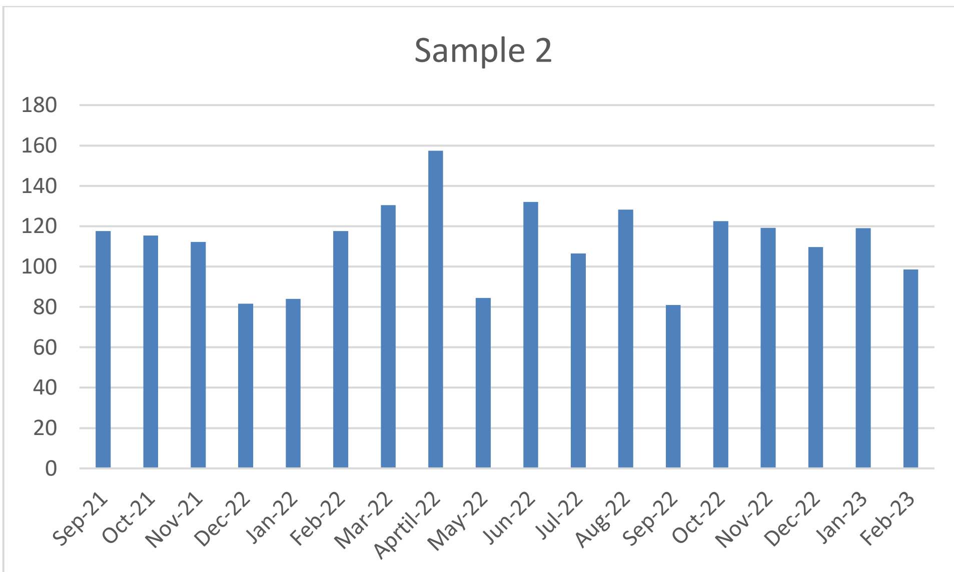

Figure 2. WQI variations for Sample 2 (tanker water)

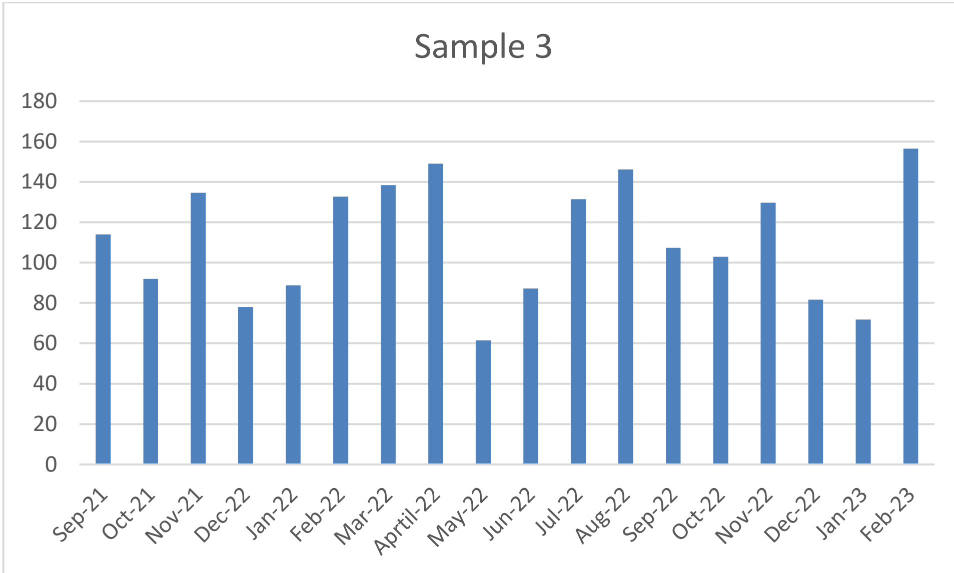

Figure 3. WQI variations for Sample 3 (tanker water)

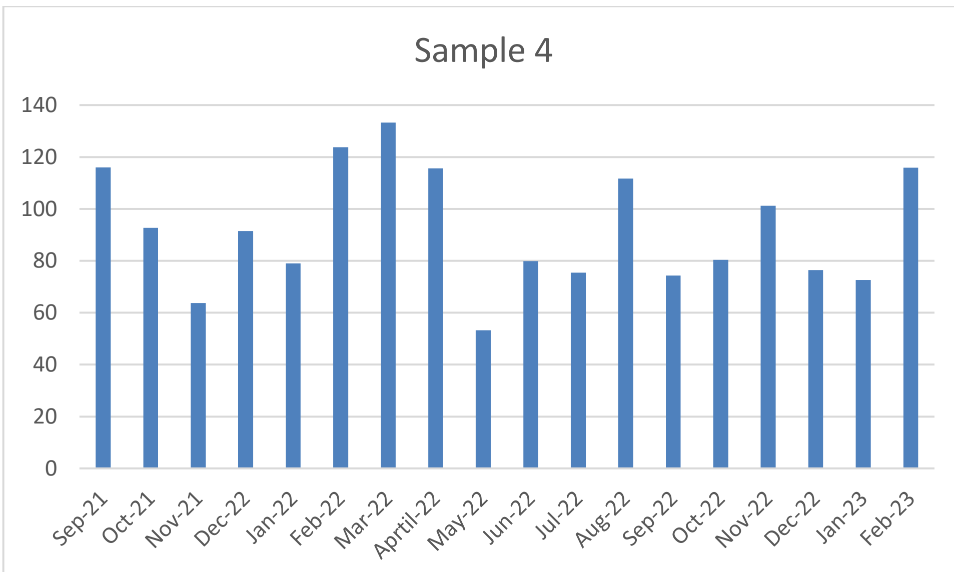

Figure 4. WQI variations for Sample 4 (tanker water)

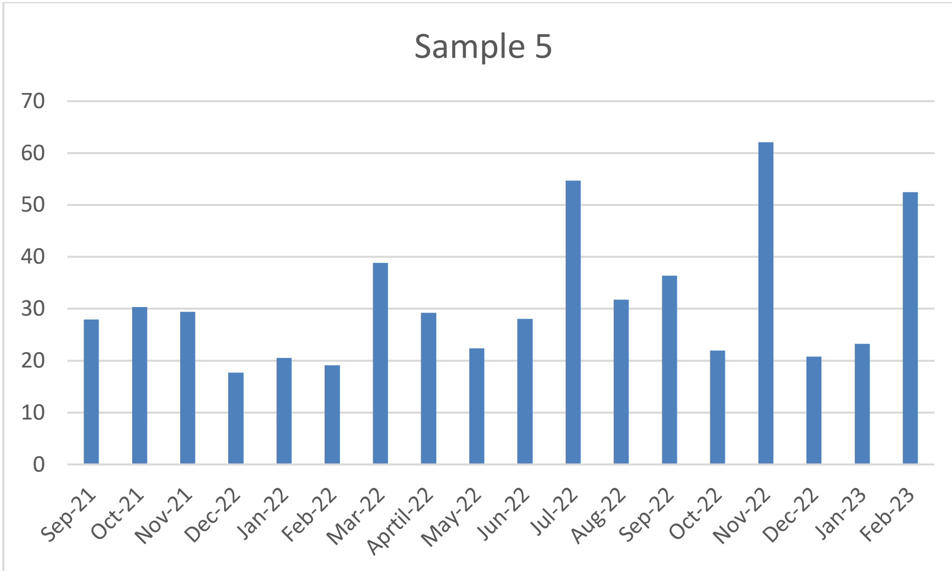

Figure 5. WQI variations for Sample 5 (tanker water)

CONCLUSION

Certain countries in the world like China, Nigeria, Pacific Island countries and territories have faced drinking water pollution and accidents in past. [21, 22, 23]

Assess to clean and safe drinking water, hygiene and sanitation are essential for improving the living standards of people. Improvement in this sector can reduce poverty, promote equality and help to support the socioeconomic development of the nation. [24]

This survey was restricted to the residents of Kudlu which is a rural area in Bengaluru. Responses were collected via Google forms among apartment dwellers who have access to internet facilities and are well educated about technology. Language and access to internet was a barrier to collect the data from poor people of the area as most of them spoke only the local languages. However, effort was made to cover as many houses in the area as possible in order to minimize bias. Since the survey was restricted to the residents of this village in Bengaluru, the results cannot be generalised or extrapolated to the general public. Moreover, the sources of water, local awareness and schemes conducted by the government and NGO might vary from place to place.

The results of the current study indicate that the apartment dwellers of the area seem to be aware of proper water usage, hygiene and sanitation. However, the poor and uneducated people living in this underdeveloped area in Bangalore are not much aware about cleanliness, good washing practices, proper hygiene and sanitation. This may be attributed to the better education of the apartment residents as most of them are graduates and above. Literacy level was found to be low among the economically poor people of the area where most of the people studied till intermediate or matriculation. This might be the reason for them of not following hand washing practice, using water without any treatment and the resultant water borne diseases. Hence, the swach Bharat initiative started by the Government of India in 2014 is not having much effect on the uneducated people in kudlu area of Bangalore where majority of them are found to be ignorant and unaware about hand washing practices; some still practice open defecation as around 6% did not have toilet facility at home in spite of the construction of toilets by the Government of India. It was anticipated that the people of poor socio-economic status have similar knowledge and awareness about sanitation, hygiene and hand washing like apartment dwellers in the area considering the awareness camps, advertisements and health promotions conducted by the Indian Government.

Clean and safe water is essential for the survival of life. In India child marriage is still rampant and the number of members of family are huge. Lack of awareness leads to improper sanitation, water usage and unhealthy hygiene practices. Feco-oral contamination of drinking water can cause water borne diseases like diarrhoea. These diseases pose a burden to the financial and economic sources of the country. Although initiatives are being taken by the Indian Government, free health camps and campaigns should be undertaken to raise the awareness of the poor people and importance of practicing proper hygiene and sanitation practices. Since most of the poor people in this area work as domestic helps in the apartments of Kudlu, initiative might be taken by the apartment dwellers to raise awareness about basic hygiene, sanitation and wash practices among them by educating them and conducting health talks.

This research attempt gives a clue to examine other critical workable factors such as examining the water quality at this specific semi-rural village Kudlu as cases of water-borne infection is reported here.

The tanker water samples of kudlu area of Bangalore were studied for a period of 18 months. A remarkable difference was noted between the water quality of tanker s compared to the purified water sample. The water quality index was found to be less than 50 (excellent as per WQI classification) for the purified water for almost all the months tested, however, it was more than 100 for most of the time period for the tanker water. Microbiological contamination with *E.coli* was also observed for few months for the tanker water samples. Hence, the tanker water is quality is poor as per the WQI classification and not at all suitable for direct consumption and should be boiled or filtered before domestic usage.

The work may be further carried out by continuing analysis of the supplied water samples in this area.

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