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ASSESSMENT OF VARIOUS INDUS WATER LOCATIONS FOR QUALITY THROUGH MATHEMATICAL MODEL

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ABSTRACT

The surface water quality of the Indus River from the Sukkur Barrage, the Rohri canal at Khairpur, and Mirwah Khairpur City was examined. Sukkur and Khairpur were chosen as the two cities for the examination. A total of 15 water samples were taken, including 5 samples from the Rohri Canal in Khairpur, 5 samples from the Sukkur Barrage, and 5 samples from Mirwah Khairpur City. For a period of two weeks, each sampling site was visited five times. Each sample was tested for thirteen physiochemical characteristics, including temperature, taste, odor, color, turbidity, pH, alkalinity, chlorides, hardness, total dissolved solids, nitrate, and sulfate. The results were then compared to the maximum allowable limits under Pakistani drinking water standard No. Ps 1932-2002. Pakistan standard and quality controls second revision. The study's findings showed that the physicochemical parameters of odor, color, taste, turbidity, PH, hardness, and nitrate were all within the ranges allowed by Pakistan's drinking water standards. As a result, the testing laboratory deemed all of the results to be FIT and suitable for agricultural and drinking purposes.

Keywords: Surface Water Quality, Taste And Odor, Turbidity, Alkalinity.

I. INTRODUCTION

Drinking water must be devoid of any contaminants that could be harmful to someone's health. Examples of such elements include minerals, chemical compounds, and pathogenic microorganisms. A large number of the population in developing countries suffers from health issues that are caused by either a lack of access to safe drinking water or water that has been polluted by microorganisms. Poor water quality causes an around 5 million child deaths annually in developing countries [1]. The problem is made worse by fast population increase and the resulting poor management of water quality [2].

Water is transmitted through hand pumps and pipeline networks to around 66% of Pakistan. In Pakistan, estimated 40% of fatalities and 30% of all diseases and infections are seemed to be caused by low water quality. One of the main reason behind the babies and infants death in the country are caused by diarrhea and water-borne diseases, according to reports, and one of the five persons currently suffered from situation brought on by contaminated water.

Unluckily, water delivery authorities gives lack of attention to the quality of portable-water, they instead emphasize quantity above quality. In this country, quality of water is not being well monitored [3]. The issue of water quality has been made worse day by day because of various reasons i.e. lack of well-equipped laboratories, weak institutional structures and a lack of legal framework. Beside this, public ignorance is also considered as a shocking lack about water quality issue [4].

Water availability in urban areas is frequently irregular, and outbreaks of gastroenteritis and other water-borne illnesses are becoming increasingly prevalent. According to estimates, the more than three million Pakistanis who suffer from water-related ailments result in 0.1 million fatalities each year. In order to determine whether contaminated water sources or distribution system flaws are the underlying issue, it is imperative to detect it [5]. There are currently no national drinking water quality requirements in Pakistan, which abides by WHO recommendations. [6]

WATER QUALITY

For sustaining the quality, quantity and purity of food, health, life, economy, and the surrounding ecosystem, it is mandatory to preserve the quantity and quality of existing resources of fresh as well as surface water, because they perform a vital role in the survival of human beings as well as for other living organisms [7]. The main objective of SDGs (Sustainable Development Goals) is to provide easy access for all people to pure, safe and contamination-free potable water regardless of wealth, race, age, creed, and gender. Due to the contamination of surface water resources, groundwater is considered the most reliable drinking water source. Literature revealed that only 33.0% population of the world has access to and uses groundwater for domestic use and the remaining 77% world's population does not have access to contamination-free groundwater. It is also revealed that due to an increase in pollution and over-exploitation, a shortage in the availability of safe groundwater resources has been faced around the world. Groundwater is not only used for domestic purposes but also plays an important character in various stages of the nation's developing economy, viz. commerce, industry, agriculture, irrigation, and the generation of hydropower. It has been shown by research that there is a shortage of safe potable water in developing countries. Moreover, in many countries where access to potable water is available, water systems and sources are badly influenced by eugenic and anthropogenic processes. Anthropogenic parameters which predispose the availability and quality of potable water include groundwater mismanagement, rapid and systematic increase in population, haphazard urbanization, industrialization, improper waste management, disposal and ineffective water management policies. It is revealed by investigations that approximately 884.0 million people in the world utilize contaminated water resources for domestic use. The use of contaminated water imparts adverse health impacts on both the consumers and the environment, also a nation's economy and food security are badly warned when contaminated water is utilized in agriculture and industry [8].

The literature revealed that groundwater is the major source of drinking and about 1/3rd of the world's population uses that for consumption purposes. Ecological functions and aquatic ecosystems are severely affected because of the degradation of water quality. Therefore, for avoiding human health threats, it is necessary to assess and improve the quality of potable water. The quality of potable water should be assessed based on physical, biological and chemical parameters [9].

It is revealed that Pakistan is considered the world's 6th most populated country having a total population of approximately about 210 million. In Pakistan, there are serious threats against public health because of the contamination of potable water. About 90.0% of potable water resources in Pakistan do not meet the WHO standards and are categorized as low water quality resources [10].

In the province of Sindh, about 36.0% of people use potable water, vegetables and fruits that are polluted with arsenic that exists beyond the WHO guidelines for drinking water [11]. It was reported that 68% peoples of rural areas consume drinking water of poor quality and approximately 44% of people do not have availability of safe water for domestic purposes in Pakistan [12].

Due to the increase in the pressure on the water supplies, groundwater contamination problems are taking place around developing countries. In Pakistan, more than 50% of people consume contaminated water. It was reported by WHO and UNICEF that approximately 2.5 billion people residing in developing areas do not have the availability of essential sanitary works and about 780 million peoples use unsafe potable water for domestic purposes. As a result, about 2.3 billion people residing in different areas across the world were affected by water-related diseases [13].

Like other areas of the country, the quality of drinking water is not good and does not meet the WHO standards and in most of the rural as well as urban areas contaminated groundwater is used for domestic purposes. A large amount of groundwater is contaminated with pathogens, chemicals, and poisonous substances. The literature revealed that major four contaminants are the main cause of poor-quality water in Sindh viz. 24% arsenic, 69% bacteria, 5% fluoride and 14% nitrate. The aim of this research is to investigate the effect of silica fume and nylon fiber on mechanical properties and workability of concrete.

GEOGRAPHICAL LOCATION OF AREAS

SUKKUR

Sukkur is the city situated in Sindh province of Pakistan along the western bank of Indus River, directly across from the Rohri which is one of the historic city. Sukkur is the 14th largest city of Pakistan and in Sindh province it is come after Karachi and Hyderabad as a 3rd largest city by population. During the British era, New Sukkur was established alongside the village of Sukkur. Along with the hill on the river island of Bukkur, Sukkur's hill form what is sometimes considered the "Gate of Sindh"

From the larger town of Rohri, the village of Sukkur was directly across, it was considered as a major trading centre for agricultural produce and also referred as a busy port by the 1200s along the Indus. At Sukkur's shrine of Mir Masum Shah 1607, an 86 foot (26m) heightened minaret was built.

There was one of the first bridges to cross the river named as Sukkur's Lansdowne Bridge which connects the Sukkur to Rohri across the Indus.

Sukkur Barrage (earlier called as Lloyd Barrage), controls a biggest irrigation system around the world, and it was built during the British Raj on the Indus River. Sir Arnold Musto KCIE designed the Barrage and between 1923 and 1932 it was made under the supervision of Sir Charlton Harrison. The barrage is 1524m aur 5001 feet high and it is made of steel and yellow stone. The Barrage consist of 7 canals, three on the right bank (North Western , Rice, Dadu) and 4 on left bank (Feeder East, Khairpur Feeder West, Rohri, Nara and Khairpur).

KHAIRPUR MIRS

Khairpur is the capital city of Khairpur District in Pakistan's province of Sindh. In Pakistan, Khairpur is the 46th largest city by population. The canals through the districts of Khairpur, Tharparkar, Sanghar and Mirpurkhas to the Jamrao Canal runs from above the Sukkur Barrage. In Pakistan, the nara canal is running for about 226 mi / 364 km and called as a longest canal. It discharges 14,145 cu ft/s (400.5 m3/s), however, it has a designed capacity of 13,602 cu ft/s (385.2 m3/s). This canal irrigates about 2,000,000 acres (8,100 km2) of land.

People are consuming the water which is not safe for their health and the agricultural purpose as well. Therefore this study has been proposed to analyze the suitability of surface water for drinking and irrigation use.

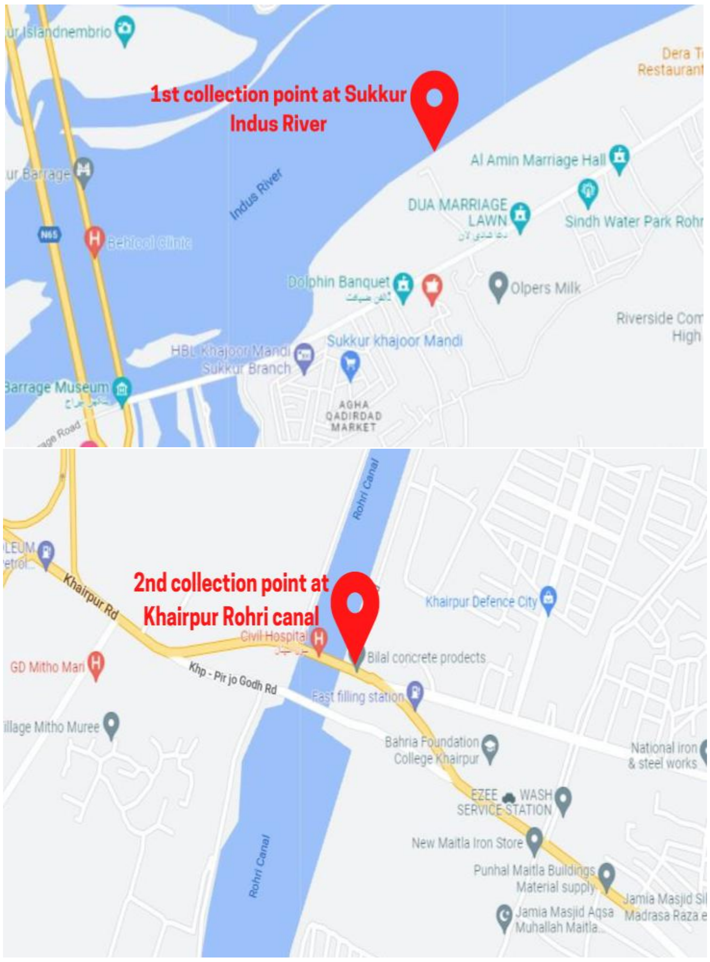

Fig 1: Collection points: Sukkur's Indus River near Olpers Factory dump Wastewater and Khairpur's Mirwah canal

The aim of the study is to investigate the suitability of Indus River Water for drinking and irrigation purpose. The exact objectives of the study are:

- To analyze the physicochemical parameters of the Indus River at the chosen site.
- To assess the surface water quality for drinking purpose using water quality index (WQI).

Researchers [14] examined the water in Tandojam, Pakistan, to see if it was safe for people to use. After analyzing some physical and chemical properties, it was found that the only measurement within the recommended levels by WHO in all the samples was Boron. However, all the other measurements such as TH, EC, pH, TDS, turbidity, Cl ion, Al, SO42-, and NO3 exceeded the recommended limits. Due to its salty taste and high mineral content, the water was found to be unsuitable.

Experimentalists [15] studied the quality of water on the surface and underground in the Sindh district of Badin in Pakistan. According to the literatures, people in the Badin district didn't have enough water, so they drank water from lakes and ponds and used a little bit of underground water. High salt levels in water also made the water dirty and harmed both the surface and underground water. This caused different health issues for people. We took 175 samples from the coastal area to investigate. Out of all the samples, 70% were polluted and didn't meet the WHO's drinking water standards. So, these samples were not safe to drink. Authors [16] According to the study, the Indus Delta region's surface water quality is poor and contains high concentrations of contaminants such nitrates, phosphates, and heavy metals. It was discovered that the WQI and SPI readings were below the allowable limit, pointing to a high amount of pollution in the area. According to the study's findings, agricultural and industrial operations, as well as the absence of adequate sanitary facilities in the area, are the main causes of the poor water quality in the Indus Delta region. To raise the quality of the water, the authors contend that the region's water resources need to be well managed and treated. Additionally, they contend that the use of WQI and SPI as complementary indicators can lead to a more thorough understanding of water quality because WQI is a composite index that combines various parameters to provide an overall assessment of water quality and SPI is a single-parameter index that measures the pollution of a water body based on a single parameter. Researchers [17] report a study on the Ranjit Sagar wetland's water quality, which is located on the Ravi River in India's Indus River system. The Water Quality Index (WQI) is used by the authors to assess the wetland's water quality. In the wetland, water samples were taken from several sources, and the samples were then tested for a variety of physic-chemical factors, including pH, total dissolved solids, total hardness, nitrate, phosphate, chloride, and heavy metals.

II. METHODOLOGY

SAMPLING METHODOLOGY

1. To Examine of the ecological features of the Indus River at the chosen site.

- 15 Samples will be collected every month from August 2022 to December 2022 from following three different locations :

a) Sukkur Barrage (near Industrial Waste)

b) Mirwah Canal (near domestic waste water and solid waste)

c) Rohri Canal (no any disposal)

- The samples will be collected in one-liter plastic bottles using all the available standards.

2. To analyse the water quality by the application of (WQI) for drinking purpose

- Based on the analysis results of different physicochemical properties as stated above, the quality of the Indus river water for domestic uses will be analyzed using the WQI model.
- The WQI model is a mathematical apparatus which is widely used around the globe by different scholars [18] [19] [20] for assessing the overall groundwater and surface water suitability for the purpose of drinking.

ASSESSMENT OF THE OVERALL QUALITY OF SURFACEWATER FOR DRINKING PURPOSES USING THE WQI MODEL

"To assess the surface water quality for drinking purposes, the Water Quality Index (WQI) was calculated based on selected physiochemical parameters. The parameters included pH, temperature (T), dissolved oxygen (DO), turbidity (Turb), electrical conductivity (EC), total dissolved solids (TDS), nitrates (NO3-), phosphates (PO4^3-

), and total coliform (TC). The WQI was calculated using the weighted arithmetic mean method. The formula used for the WQI calculation is as follows:

$$WQI = \Sigma(Wi * Si)$$

Where WQI represents the overall water quality index, Wi is the weight assigned to each parameter (based on its relative importance), and Si is the sub-index calculated for each parameter. The sub-indices were determined using the following formula:

$$Si = (Ci - Di) / (Hi - Di)$$

Where Ci represents the concentration of the parameter in the water sample, Di is the desirable concentration value, and Hi is the maximum permissible concentration value. Desirable and maximum permissible values were obtained from drinking water quality standards or guidelines. The individual sub-indices were then combined to derive the overall WQI score, providing a comprehensive assessment of surface water quality for drinking purposes."

ASSESSMENT OF SURFACEWATER QUALITY FOR IRRIGATION PURPOSES USING IRRIGATION INDICES

Based on two types of irrigation models such as RSC and MHI, the groundwater quality would be assessed for the agriculture purpose in the proposed study area. These irrigation models are briefly elaborated on below.

RSC (Residual Sodium Carbonate): RSC would be calculated by knowing the concentration of CO32- (carbonate), HCO31- (bicarbonate), Ca2+and Mg2+ in the sampled water. All ionic concentrations are taken in milli equivalent per litre (meq/L).

$$\text{Residual Sodium Carbonate (RSC)} = (CO32- + HCO31-) - (Ca + Mg)$$

Groundwater having an RSC index<2.5 meq/L will be considered fit for irrigation purposes. On the other hand, groundwater with an RSC index >2.5 meq/L would not be acceptable for irrigation purposes (Solangi et al. 2019). MHI (Magnesium Hazard Index)

After determining the concentrations of Ca2+and Mg2+ ions of the sampled water, the MH index can be evaluated with the help of the following model explained as under. The Ca2+and Mg2+ionic concentrations are taken in milli equivalent per litre (meq/L).

$$\text{Magnesium Hazard Index (MHI)} = Mg^{(2+)}/(Ca^{(2+)}+Mg^{(2+)})\times 100$$

As per this model, sampled groundwater will be considered fit for the irrigation purpose if MHI is <50 and groundwater will not be suitable for irrigation if MHI is >50 (Solangi et al. 2020).

Colour

Pure water is considered as a colorless because it doesn't contain any color. Drinking water imparted colour in these ways i.e by dissolved and suspended elements. The crystal clear color of pure drinking water could be changed in light dark colour due to the presence of different contaminants and that color difference can be visualized with the naked eye. That's the reason, the sensory method i.e the colour of surface water samples was figured out with the help of naked eye.

Odour

The term Odour is referred as an unpleasant and unwanted smell present in water, that's why every sample was analysed by nose to check that either the water is odourless or not, If an unwanted smell present in water then it shows the presence of impurities and contaminants which means the water is of low quality.

Taste

A water is considered as a pure if it is odourless, colourless and has a pleasant taste. Assessment of water was taken place that either it is sour, bitter, sweet or salty by taste up to a certain limit or not, because excessive of those tastes indicates the presence of excessive compounds. Each sample of water was tasted by sipping water or tasting water by tongue. Presence of excessive compounds shows the impurities in water which shows negative impact on health of individuals or consumers of water which may cause many diseases.

pH

In any solution pH shows the hydrogen ion concentration and also indicates the intensity of alkalinity and acidity of water. The pH of water was assessed to determine that how much water is saline or acidic in nature. This test was conducted with the help of pH meter. According to pH meter the water is considered as acidic if

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pH is less than 7, and if it is beyond 7 than water is alkaline in nature. The neutral water has exactly the pH of 7 that is neither acidic nor alkaline. If the pH of water is higher than the allowable range then it may severely effect on human health. EPA recommend that the pH must be between 6.5 to 8.5 of suitable drinking water, the pH of each collected sample was examined by the use of digital pH meter (Fig 3.3) and its calibration was done by the buffer solution. The digital pH meter's little stick was put in the beaker of water, and we looked at the numbers on the meter and wrote them down in a notebook to see how acidic or basic the water was.

Turbidity

The amount of light that is absorbed or dispersed by water particles is known as turbidity. When silt, clay, algae, and other coloured chemicals are suspended in water, it occurs. The water is opaque and hazy as a result of these suspended particles. The proliferation of pathogens in the water distribution system is accelerated by turbidity, which gives rise to a wide variety of bacteria and pathogens. Consuming turbid water can also result in the spread of several waterborne illnesses, including gastroenteritis and other similar conditions. The acceptable turbidity level for drinking water according to the WHO is 5 NTU (Nephelometric Turbidity Unit). In addition to being unsightly, excessive cloudiness or turbidity in drinkable water is bad for human health. It's commonly understood that river water is murky and sluggish, and that it is difficult to see clearly through river water, a sign of excessive turbidity. While spring water is thought to be highly clean and translucent with little turbidity. The water is turbid because of sand, silt, muck, algae, and other colloidal or suspended particles. Using a turbidity meter that had been thoroughly calibrated using the standard solution, the turbidity of each sample that had been collected was measured in the current investigation.

Total Dissolved Solids

The main thing used to decide if water can be used for irrigation, industry, or at home is the total amount of dissolved solids in it. TDS means the mix of salts in water. TDS occurs mainly due to certain substances called anions and cations. The anions that cause TDS include CO32-, HCO31-, Cl-, SO42-, and NO31-. The captions that contribute to TDS are Ca2+, Mg2+, Na+, and K+. The TDS is the amount of salts left behind when water is evaporated. The World Health Organization (WHO) suggests that the amount of total dissolved solids (TDS) in drinking water should be around 500 mg per liter. However, some researchers believe that a slightly higher level of 600 mg per liter is considered to be the best. In the year 2019. Based on the research by Saleemet and colleagues, In 2016, water is considered not safe to drink if it has more than 1000 mg/L of TDS. This is because it can cause stomach problems for people who drink it.

People who drink water with too many TDS can have bad health effects, and it also affects their household appliances. However, water with a very small amount of dissolved minerals is believed to have no taste and can harm the water pipes by causing them to corrode.

III. RESULTS AND DISCUSSION

3.1 pH

According to the WHO's drinking water guidelines, the pH of water should be between 6.5 and 8.5. However, in the present study, pH analysis showed that all of the samples had pH values ranging from 6.80 to 8.00, with a mean value of 7.440.25 as shown in Fig. 1.

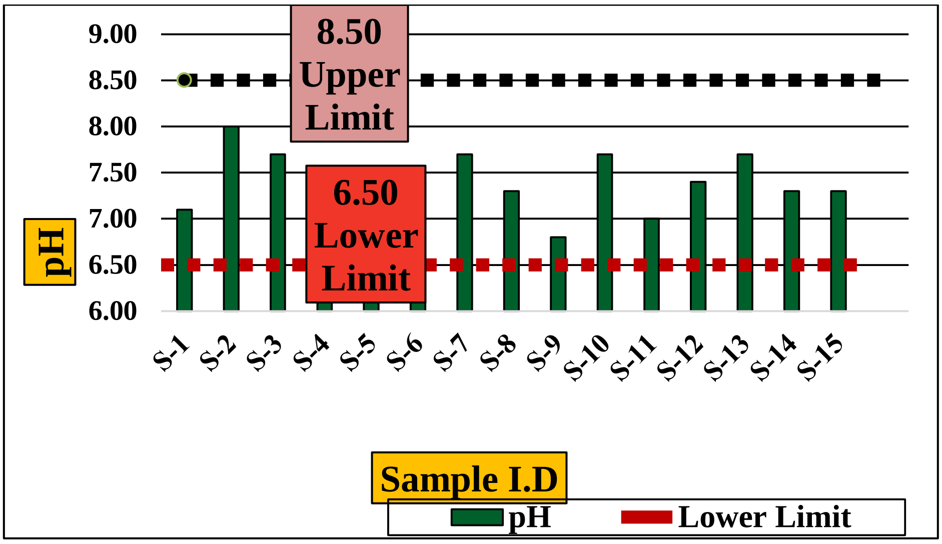

Figure 1: Graphical representation of pH of sampled water

3.2 TURBIDITY

WHO guideline of turbidity for drinking water is recommended as 5 NTU. Analysis revealed that in the current study turbidity of the sampled water varied between 75 and 180.50 NTU with an average concentration of 99.37 NTU. Turbidity of 26.66% samples was found beyond the WHO guideline of 5 NTU as described in Fig. 2.

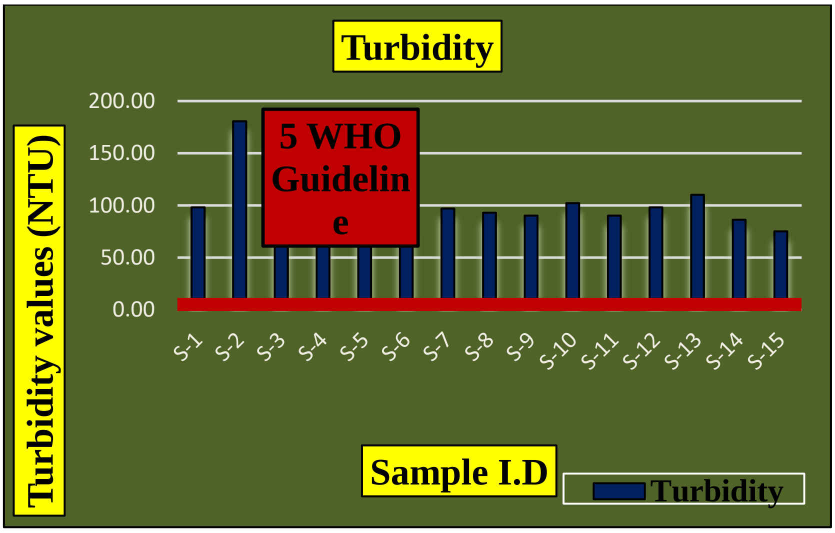

Figure 2: Graphical representation of turbidity of sampled water

Fig. 2 depicted that 100% of samples crossed the WHO guideline of 5 NTU, having a maximum concentration of 180.50 NTU. Maximum turbidity was found in the water of location S-2, While the least turbidity value was observed in the surface water of S15 location having a minimum concentration of 75 NTU. The remaining 73.33%of samples were found with turbidity within the WHO guideline. It was concluded that in terms of turbidity surface water was not considered fit for drinking.

TOTAL DISSOLVED SOLIDS (TDS)

The WHO recommends a TDS concentration of 1000 mg/L for drinking water. TDS concentration was found to vary between 197.0 and 993.0 mg/L in the current investigation, with a mean concentration of 421.870±214.98 mg/L as shown in Fig. 3.

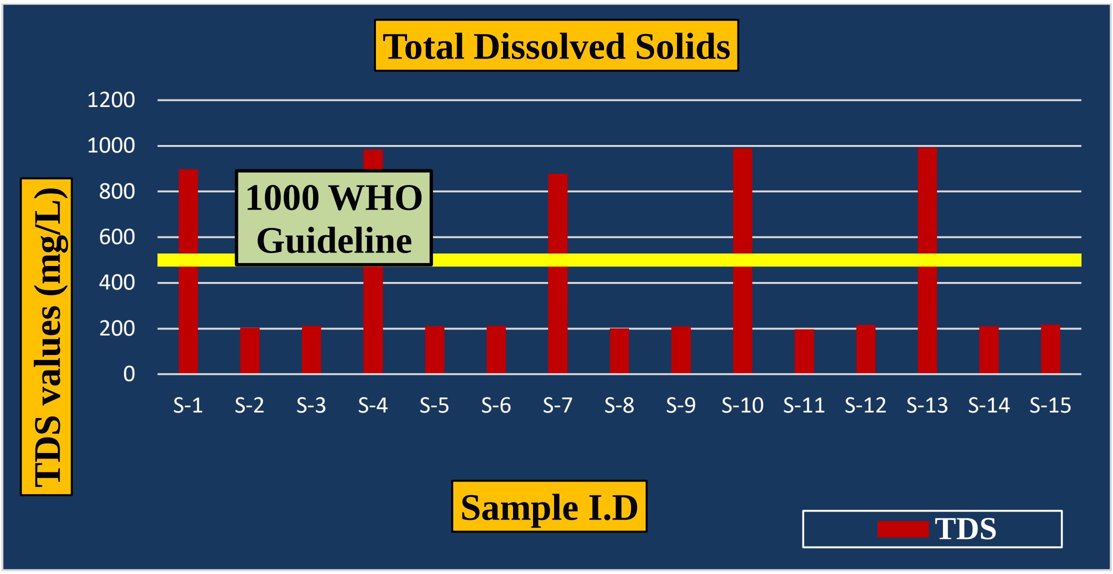

Figure 3: Graphical representation of TDS of sampled water

Figure 3 showed that, out of 15 samples, 5 samples, or 33.33% of the samples, had TDS concentrations over the permissible WHO standard of 500.0 mg/L. The remaining 10 samples were discovered to be within the permitted range. The surface water at position S-13 had the highest TDS content, whereas water at location S-11 had the lowest TDS concentration. The surface water aquifer was being continuously replenished, and dissolved contaminants were being eliminated by aquifer recharge, which is likely the cause of the least TDS. The water source was constructed on the side of a canal known as West Feeder. According to analysis, 66.67% of the samples fell within the WHO's recommended limit of 1000 mg/L.

ELECTRICAL CONDUCTIVITY (EC)

WHO electric safety guidelines It is advised to have water with a conductivity of 0.75 dS/m or 400 S/cm. According to the current investigation, EC was shown to range between 0.31 and 1.55 dS/m, with an average concentration of 0.660±0.340 dS/m as shown in Fig. 4.

According to Fig. 4, out of 15 samples, 5 samples, or 33.33%, had EC levels that were higher than the WHO's permissible threshold of 0.75 dS/m. According to analysis, 66.67% of samples had EC concentrations that were within the WHO's recommended range of 0.75 dS/m. The water at position S-13 had the highest had the lowest concentration of EC. In terms of EC, it was determined that 66.67% of the samples were good, safe, and appropriate for home use.

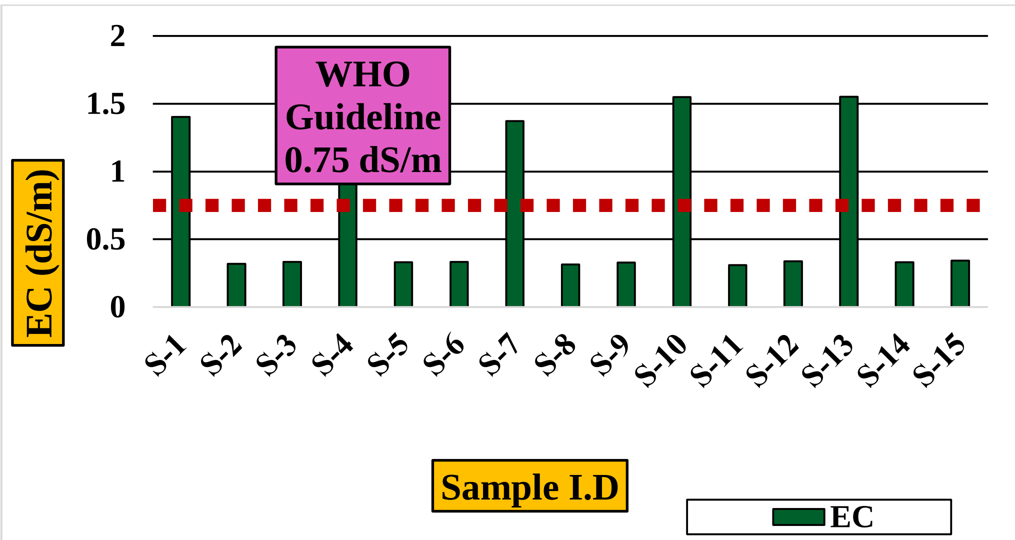

Figure 4: Graphical representation of EC of sampled water

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Table 1: Analysis results of physicochemical characteristics of sampled water

Area	pH	Turbidity (NTU)	TDS (mg/L)	EC (dS/m)	Cl- (mg/L)	TH (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	CO_3^{2-} (mg/L)	HCO_3^{1-} (mg/L)	SO_4 (mg/L)
S-1	7.10	98	897	1.4	35.4	140	112	33.6	0	165	87
S-2	8.00	180.5	204	0.319	106	140	40	9.7	0	200	79
S-3	7.70	95	212	0.332	71	95	40	9.7	0	135	31
S-4	7.10	101	984	1.539	71	120	104	34	0	150	23
S-5	7.50	90	211	0.331	35	135	48	3.6	0	160	28
S-6	7.40	85	212	0.332	17.7	100	52	4.8	0	145	78
S-7	7.70	97	878	1.373	71	115	100	32.8	0	185	87
S-8	7.30	93	201	0.315	17.7	105	60	10.9	0	200	82
S-9	6.80	90	209	0.328	35.4	105	44	1.2	0	155	77
S-10	7.70	102	990	1.548	76	120	100	32.8	0	185	71
S-11	7.00	90	197	0.309	16.7	105	44	1.2	0	140	76
S-12	7.40	98	216	0.338	18	90	48	7.2	0	145	81
S-13	7.70	110	993	1.552	78	105	100	32.8	0	185	90
S-14	7.30	86	211	0.33	17.7	120	52	2.4	0	150	80
S-15	7.30	75	218	0.342	35.4	95	48	6	0	160	77

Table 2: Summary of statistical analysis of physical and chemical parameters of sampled surface water

Parameter	Min.	Max.	Average	SD	WHO guidelines	(%) Samples beyond guidelines
Ph	6.80	8.00	7.40	0.32	8.5	0
Turbidity	75.00	180.50	99.37	23.93	5	100
TDS	197.00	993.00	455.53	362.02	500	33.33
EC	0.31	1.55	0.71	0.57	0.75	33.33
Cl^-	16.70	106.00	46.80	29.15	250	0
TH	90.00	140.00	112.67	16.24	500	0
Ca^{2+}	40.00	112.00	66.13	27.71	75	33.33
Mg^{2+}	1.20	34.00	14.85	13.75	50	0

CO_3^{2-}	0	0	0	0	15	0
HCO_3^{1-}	135.00	200.00	164.00	21.65	120	100
SO4	23.00	90.00	69.80	22.55	1.5	0

IV. CONCLUSION

Based on the physicochemical analysis, mathematical model and GIS mapping, the following conclusions are made.

Analysis of Physicochemical Parameters

Based on the sensory tests, all the observed water samples were found colourless, odourless and had a pleasant taste. Hence, it was concluded that, in terms of colour, odour and taste groundwater of the studied area was considered excellent, safe, and suitable for domestic use.

Also, pH in the sampled water was observed between 6.8 and 8 with an average concentration of 7.40±0.25.

Turbidity was observed between 75 and 180.50 NTU with a mean concentration of 99.37±3.29 NTU. Overall water quality of the study area was not considered good in terms of turbidity.

TDS in the sampled water was observed between 197.0 and 993.0 mg/L with an average concentration of 455.53±214.98 mg/L. In terms of TDS, surface water was considered good, safe, and suitable for drinking.

EC was observed between 0.31 and 1.55 dS/m with an average concentration of 0.71±0.340dS/m.

Chlorides in the sampled water were observed between 16.70 and 106.0 mg/L with an average concentration of 46.80±11 mg/L.

Ionic concentrations of Ca2+ and Mg2+ in the sampled water were observed from 40 to 112 mg/L and 1.2 to 34 mg/L with average concentrations of 66.13±60 mg/L and 14.85±2 mg/L respectively. However, total hardness was observed between 120 and 680 mg/L with an average concentration of 348±152.40 mg/L.

It was found that the pH of all the samples was recorded within the WHO guideline of 6.5 to 8.5, therefore the concentration of carbonate (CO32-) was found to be zero for all samples, which indicates very less alkalinity in the water samples, whereas the concentration of bicarbonate (HCO31-) varied between 135 and 200.0 mg/L with a mean content of 164±102.88 mg/L.

Analysis of Biological Parameters

Calcium content was found between 25.1 and 104.61 mg/L with a mean concentration of 71.06±21.83 mg/Magnesium content was found between 5.76 and 52.56mg/L with an average concentration of 29.88±12.30 mg/L.

Sodium content was observed between 22.88 and 198.21 mg/L with an average concentration of 77.49±46.06 mg/L. Potassium was found between 3.94 and 94.27 mg/L with an average level of 20.47±26.68 mg/L.

Overall physicochemical and heavy metals analysis revealed pH, carbonate (CO32-), calcium (Ca), sodium (Na), potassium (K), iron (Fe), manganese (Mn), nickel (Ni), zinc (Zn), boron (B), arsenic (As), copper (Cu), cobalt (Co), chromium (Cr)were within the standard WHO guidelines. However, about 27%, 33%, 33%, 20%, 13%, 80%, 53%, 80%, 47%, 80%, 6.67% and 6.67% of the samples had turbidity, TDS, EC, Cl-, TH, Ca2+ (as CaCO3), Mg2+ (as CaCO3), HCO31-, Mg (metal), molybdenum (Mo), cadmium (Cd) and fluoride concentrations beyond the allowable WHO drinking water guidelines.

V. REFERENCES

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