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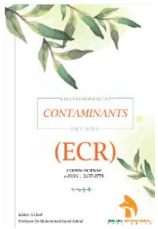

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RESEARCH ARTICLE

COMPARATIVE STUDY OF GROUND AND SURFACE WATER QUALITY ASSESSMENT USING WATER QUALITY INDEX (WQI) IN MODEL COLONY MALIR, KARACHI, PAKISTAN

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ABSTRACT

This study covers the evaluation of the quality of ground water and surface water using water quality index (WQI) for drinking purpose of Model Colony, Karachi, Sindh, Pakistan based on parameters physical, chemical, biological and heavy metals. The ground water samples were collected through boring wells and surface water samples were collected from (KWSB) Karachi Water and Sewerage Board's water supply system from different locations of study area. Four different locations were selected for collection of water samples using sterilized plastic bottles (1.5L capacity) from 9C, Kazimabad, Abbasi market, and Surti Society. Sampling was done in the evening time (05:00 pm PST). The results were compared with the WHO guidelines. It is concluded that some parameters like Lead and Fecal Coliform (E. coli) are found above from WHO guidelines, some like Arsenic, pH, Turbidity, Total Alkalinity as (CaCO3), Calcium, Chloride, Hardness (CaCo3), Magnesium, Nitrate, Potassium, Sodium, Sulphate and TDS are found below from WHO guidelines. For Water Quality Assessment Weighted Arithmetic Index method is used. WQI categorizes the both sources of water of Model Colony as good quality water. The mixing of sewage water which may infiltrate from the river channels and nala surrounding the study area, results in decreased quality of water. Calculated value of WQI revealed that the ground water with WQI= 25.60 and surface water with WQI= 29.38 are grouped into good category of water quality which indicates that it is unfit for drinking purpose. However, it can be used for the domestic, irrigation and industrial use. However, it can be used Over all public opinion was recorded through checklist at Model Colony causing various health ailment problems. The survey shows that persons found having diseases like Diarrhea 90%, Hepatitis-A 15%, Skin 70%, Eyes problem 45% and Typhoid 65%.

KEYWORDS

Physical, Chemical, Biological and heavy metal parameters, water quality index, Model Colony, Malir, Karachi.

1. INTRODUCTION

Water is an essential requirement of human life and activities associated with industry, agriculture, and others, and it considers one of the most delicate parts of the environment (Sanjrani et al., 2017). In the last few decades, the accelerated pace of industrial development and progressive growth of population caused in tremendous increase in the demand of fresh water (Ramakrishnahiah et al., 2009). The quality of surface and ground water is identified in terms of its physical, chemical, and biological parameters (Loukas 2010). The water quality of surface and ground water is characterized by a high level of heterogeneity in time and space, because of the distinction of cover-land around. This often creates difficulties to identify water conditions and pollution sources, which is necessary to control effectively pollution in addition to construct successful strategies for minimizing of contamination resources (Singh et al., 2005). Anthropogenic pollutants related to land use result in drastic deterioration of aquatic systems in ground and surface water (Massoud et al., 2006). Additionally, the ground and surface water play an important role in assimilating municipal and industrial effluent as well as runoff from Agricultural land and the surrounding area in a watershed (Sigua et al., 2003).

Human activities in particular husbandry livestock and agriculture play an important role in contributing contamination of ground and surface water among others pollutants. Waste water of livestock contains high concentrations of ammonia nitrogen, organic and inorganic nitrogen compound, and pathogenic bacteria, reported that ground and surface water of Model Colony in which human activities associated with urbanization, mixing of sewage water in water reservoirs during rainy seasons, industrialization, and agricultural activities are extremely main sources of pollution (Gasim et al., 2009). Industrialization and emergence of urban units placed immense stress on water resources and discharge of wastewater into natural water resources that decreases ground and surface water quality (Awan et al., 2002). Most of the previous studies

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about water resources have focused on agriculture, the power industry, the petroleum refinery industry, the dyeing and finishing industry (Sanjrani et al. 2019; Chen et al., 2016; Zhang et al., 2016; Sanjrani et al. 2018; Bakken et al., 2016; Mughees et al., 2015; Takama et al., 1980).

Karachi is the biggest and densely populated (more than 20 million population) city of Pakistan, which is facing the problem of municipally supplied water shortage since many years. It is the main reason that residents of Karachi are rapidly switching over to the ground water for drinking and other domestic uses. This present study is aimed at screening the quality of ground water and surface water. Model Colony is selected due to a reason that it is densely populated area, where many families are settled since the birth of Pakistan. Other objective of this study is to apply Water quality index (WQI) method to classify the ground and surface water of Model colony for various purposes.

2. Objective of Study

The main objective of study for drinking quality of ground and surface water of Model Colony is to determine the of quantity of parameters; physical and chemical, microbiological, and heavy metals present in the water and to compare them with the WHO guidelines and apply Water quality index (WQI). In this study we will discuss the reasons for the addition of contaminants in the water causing drinking water polluted, and what mitigation measures can be taken to avoid such problems and to find some solutions for the problems and how can we treat that water to make it clean as a potable/drinking water. Pakistan ranks at number 80 among 122 nations regarding drinking water quality (WHO, 2011). Pakistan ranks number 9 in the list of top 10 countries with lowest access to clean water where 21 million out of the total population of 207 million, do not have access to clean water. India, Ethiopia and Nigeria are the top three countries without safe water (Azizullah, 2011).

This study mainly depends upon the following objectives:

- Survey of location
- Sample collection at Model colony
- Physico-chemical analysis of ground and surface water samples
- Public opinion regarding health ailments
- Comparison of results with WHO guidelines
- To determine WQI of this study.

3. Materials and Methods

3.1 Area of Study

Model Colony is a town in Karachi city with geographical coordinates 24.9023° N and 67.1892° E, having area of 12.5 km² with population 383,801 according to the census 2017. Model Colony is one of the neighbor hoods of Malir Town in Karachi, Sindh, Pakistan, situated on the outer part of the city about two miles north-east of Jinnah International Airport, Karachi's international airport. Other important buildings in the surrounding are the Security Press, which is Pakistan's mint, and the SOS village which houses about 200 orphans. There are several ethnic groups in Malir Town including Sindhis, Urdu Speakers, Punjabis, Kutchi, Kashmiris, Seraikis, Pakhtuns, Balochs, Memons, Bohras, Ahmadies and Ismailis (2006).

Figure 1: Map of Model Colony, Malir, Karachi

Model Colony is famous for being one of the most peaceful areas of Karachi. It's because it is situated within a Security Triangle.

3.2 Survey and Sample Collection

During survey we have selected Model Colony because residents said they used to consume water for drinking, cooking, and for other purposes too. It was observed that the problem of mixing of sewage water into the surface and ground water was there, and it was due to the infiltration of leaked drainage system and due to mixing of waste water into surface water during rainy season which was the root cause of water contamination.

Water samples were collected from four different locations using sterilized plastic bottles (1.5L capacity) from 9C, Kazimabad, Abbasi market, and Surti Society. Sampling was done in the evening time (05:00 pm PST).

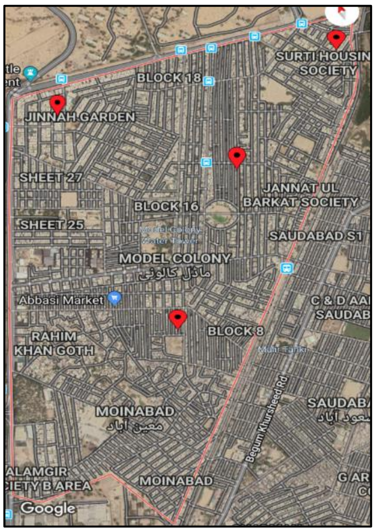

Figure 2: Sample Location map using Google map

Ground water in area is available at different depths depends upon the location, the water in average is available at the depth of 120 to 130 feet. The surface water to the Model colony is supplied from water pumping station at Damloti through the underground water supply lines by Karachi Water and Sewerage Board (KWSB). Location of samples collected areas was marked on the Google map (Fig. 2)

3.3 Analysis of water parameters

The pH and total dissolved solids (TDS) of collected samples (n = 8) were determined by using the glass electrode pH meter (Adwa AD 111) and EC meter (Adwa AD 330) respectively. Concentration of sodium and potassium were measured with flame photometer (Model No. JENWAY PFP7). Sulphate content was tested by gravimetric method, while bicarbonate by titration and chloride was estimated by argentometric titration method. Magnesium was estimated as the difference between hardness and calcium with the help of standard formula. The method used for the analysis of calcium was EDTA titration Standard Method (1992). Water samples preserved in the boric acid were analyzed to determine the nitrate concentration by cadmium reduction method (HACH-8171) on spectrophotometer.

3.4 Water Quality Index (WQI)

WQI was calculated using the standards of drinking water quality recommended by World Health Organisation threshold for drinking water quality (Yu et al., 2013).WQI is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers. It was first proposed by Horton (1965) which was later on generalized by Brown et al. in 1970. WQI is a single number that rates the water quality by aggregating several water quality parameters and usually the lower score represents the better quality (Excellent, Good) and the higher score to degraded quality (Bad, Poor). Weighted arithmetic index method of WQI proposed by Brown et al (1970) was applied to evaluate the ground and surface water quality status of Model Colony, Malir, Krachi. Physicochemical parameters including pH, TDS and major cations (Ca, Mg, Na and K) and anions (HCO3, Cl, SO4 and NO3) were used to calculate WQI of ground and surface water in Model Colony. WQI is calculated using following formula:

WQI= ∑ Qn Wn / ∑n

Where,

Qn is the quality rating of nth water quality parameter,

Wn is the unit weight of nth water quality parameter.

The quality rating Qn is calculated using the equation:

Qn = 100 [(Vn-Vi) / (Vs-Vi)]

Where,

Vn is the actual amount of nth parameter present,

Vi is the ideal value of the parameter, Vi = 0, except for pH (Vi = 7)

Vs is the standard permissible value for the nth water quality parameter.

Unit weight (Wn) is calculated using the formula:

Wn = k / Vs

Where, k is the constant of proportionality and it is calculated using the equation:

K = 1 / ∑ (1 / Vs)

4. Results and Discussions

This chapter deals with comparison of results with the WHO guidelines and comparative result analysis of water quality of Model Colony Karachi. Ground and surface water is an important natural resource for population lived around the vicinity. They provide water for domestic, industrial, fisheries and irrigation. The results which were analyzed during examination are as;

4.1 Arsenic

Arsenic is a natural metalloid chemical that may be present in groundwater. Ingestion only poses health problems if a dangerous amount of arsenic enters the body. Then, it can lead to cancer, liver disease, coma, and death. The water samples were analyzed and results were found below from WHO guidelines as shown below in table 1 and compared in Fig 3.

Table 1: Arsenic results comparison with WHO guidelines

S.No	Location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Arsenic	3.50 mg/L	2.20 mg/L	10 mg/L
2	Abbasi market		2.00 mg/L	2.38 mg/L	
3	9c		2.18 mg/L	1.75 mg/L	
4	Surti society		5.95 mg/L	1.00 mg/L	

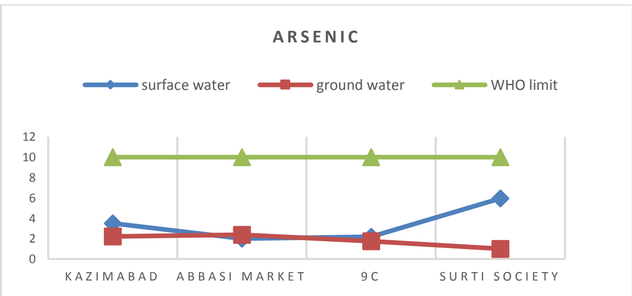

Figure 3: Arsenic results comparison with WHO guidelines

4.2 Lead

The most common sources of lead in drinking water are lead pipes, faucets, and fixtures. In homes with lead pipes that connect the home to the water main, also known as lead services lines, these pipes are typically the most significant source of lead in the water. The concentration of lead was found very high in both surface and ground water samples which is above from WHO guidelines as shown below in table 2 and are compared in Fig 4.

Table 2: Lead results comparison with WHO guidelines

S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Lead	43.0 mg/L	46.8 mg/L	10 mg/L
2	Abbasi market		38.7 mg/L	77.0 mg/L	
3	9c		39.5 mg/L	75.9 mg/L	
4	Surti society		38.9 mg/L	67.5 mg/L	

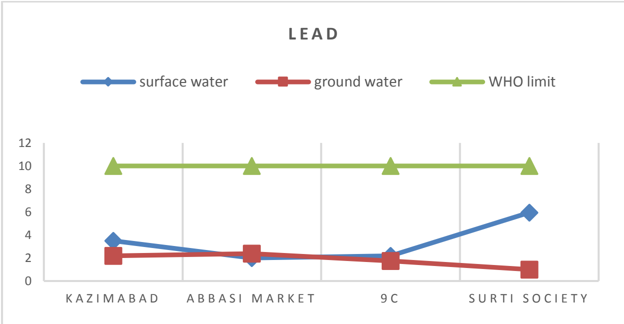

Figure 4: Lead results comparison with WHO guidelines

4.3 pH

The pH may be defined as negative logarithm of the hydrogen ion concentration. Following mathematical expression is used to determine the pH of any water.

pH = -log10 [H]

The results of pH was recorded and found little difference between surface and ground water samples which is shown in table 3 and are compared in Fig 5. The examined results of pH are in the WHO given limits due to less industries in surrounding as it is residential area.

Table 3: Figure 5 pH results comparison with WHO guidelines

S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	pH	7.69	7.23	6.5-8.5
2	Abbasi market		7.49	7.02	
3	9c		7.35	7.75	
4	Surti society		7.35	7.15	

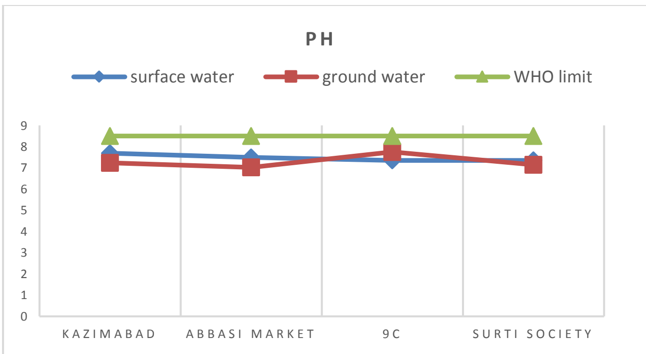

Figure 5: pH results comparison with WHO guidelines

4.4 Turbidity

The Turbidity of samples was analyzed and little difference was found between surface and ground water samples which is shown in table 4 and are compared in Fig 6.

Table 4: Turbidity results comparison with WHO guidelines					
S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Turbidity	0.42 NTU	0.59 NTU	≤5 NTU
2	Abbasi market		0.47 NTU	0.5 NTU	
3	9c		0.43 NTU	0.15 NTU	
4	Surti society		0.38 NTU	0.47 NTU	

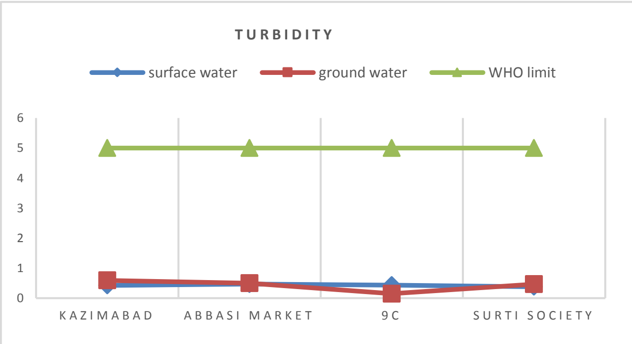

Figure 6: Turbidity results comparison with WHO guidelines

The examined results of Turbidity are in the WHO given limits. It was observed that transparency of water was not too low.

4.5 Total alkalinity as (CaCO3)

It is measured in mg/L of CaCO3. Naturally occurred alkalinity is in the range from 400 to 500 mg/L. Alkalinity is the capacity of water to resist changes in pH that would make the water more acidic. (It should not be confused with basicity which is an absolute measurement on the pH scale). The results of analyzed samples are given below in table 5 and are compared in Fig 7.

Table 5: Total alkalinity as (CaCO3) results comparison with WHO guidelines					
S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Total alkalinity as (CaCO3)	176 mg/L	268 mg/L	300 mg/L
2	Abbasi market		188 mg/L	265 mg/L	
3	9c		210 mg/L	265 mg/L	
4	Surti society		168 mg/L	288 mg/L	

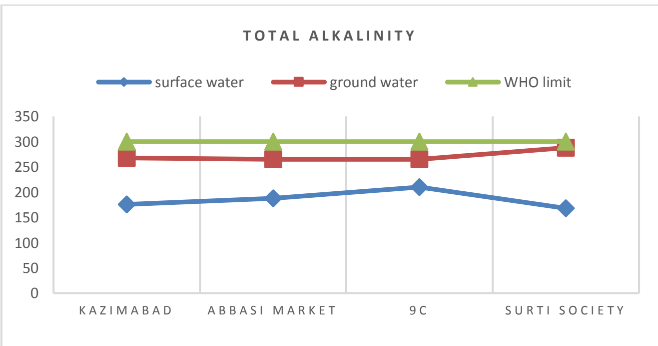

Figure 7: Total alkalinity as (CaCO3) results comparison with WHO guidelines

4.6 Bicarbonate

Bicarbonate increases with decrease in water levels. The bicarbonate (HCO3) ion is the principal alkaline constituent an almost all water supplies. If an acid is added to the water the hydrogen ion concentration is increased and this combines with both the carbonate and bicarbonate ion. The amount of bicarbonate in water is supplemented by naturally occurring carbonates such as CaCO3; rain water comes into contact with watershed soils or the streams. The analyzed results of bicarbonate are shown in table 6 and are compared in Fig 8. The WHO has not set the limit value for bicarbonate.

Table 6: Bicarbonate results comparison with WHO guidelines					
S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Bicarbonate	82 mg/L	107 mg/L	NGVS
2	Abbasi market		60 mg/L	93 mg/L	
3	9c		78 mg/L	115 mg/L	
4	Surti society		50 mg/L	117 mg/L	

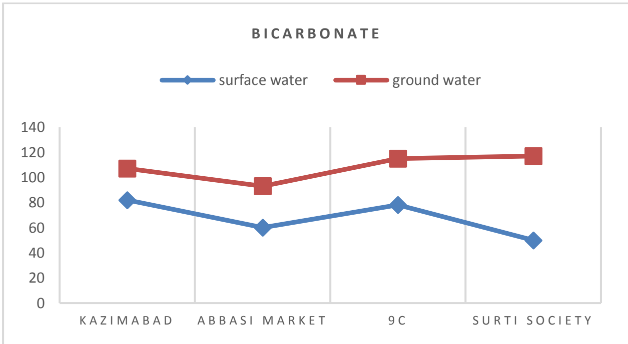

Figure 8: Bicarbonate results comparison with WHO guidelines

4.7 Calcium

The analyzed results for Calcium are shown in table 7 and are compared in Fig 9. So according to Pakistan Drinking Water Quality Standards the concentration of calcium is low.

Table 7: Calcium results comparison with WHO guidelines					
S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Calcium	49 mg/L	51 mg/L	75mg/L
2	Abbasi market		49 mg/L	59 mg/L	
3	9c		54 mg/L	49 mg/L	
4	Surti society		53 mg/L	47 mg/L	

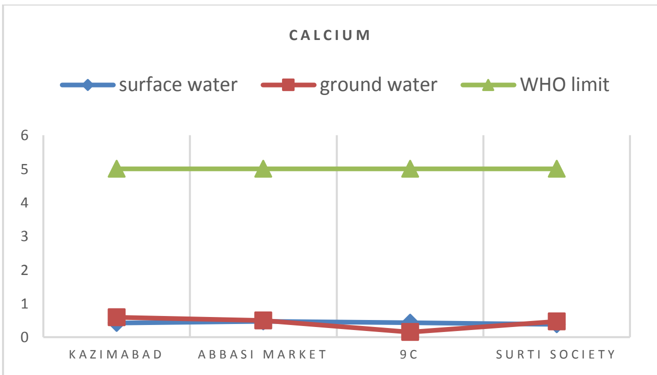

Figure 9: Calcium results comparison with WHO guidelines

4.8 Electrical conductivity

The Electrical conductivity (EC) of water was measured which is shown in table 8 and are compared in Fig 10. The WHO has not set the value of electrical conductivity.

Table 8: Electrical conductivity results comparison with WHO guidelines

S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Electrical conductivity	720 µS/cm	5274 µS/cm	NGVS
2	Abbasi market		743 µS/cm	4674 µS/cm	
3	9c		1043 µS/cm	4274 µS/cm	
4	Surti society		650 µS/cm	4874 µS/cm	

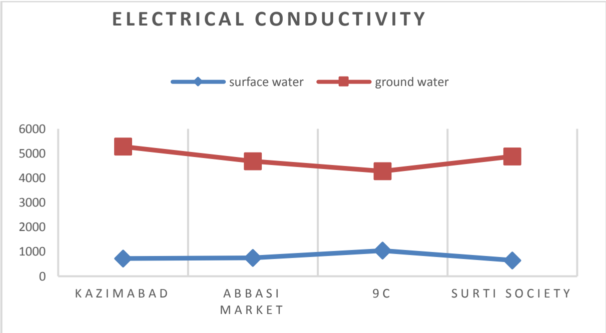

Figure 10: Electrical conductivity results comparison with WHO guidelines

4.9 Chloride

Natural water generally contains low concentrations of chlorides. Higher levels always originate from contamination by sewage and agriculture. During analyzing the concentration of chloride in water samples found below than WHO guidelines.

Table 9: Chloride results comparison with WHO guidelines

S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Chloride	72 mg/L	179 mg/L	<250 mg/L
2	Abbasi market		90 mg/L	227 mg/L	
3	9c		65 mg/L	175 mg/L	
4	Surti society		76 mg/L	193 mg/L	

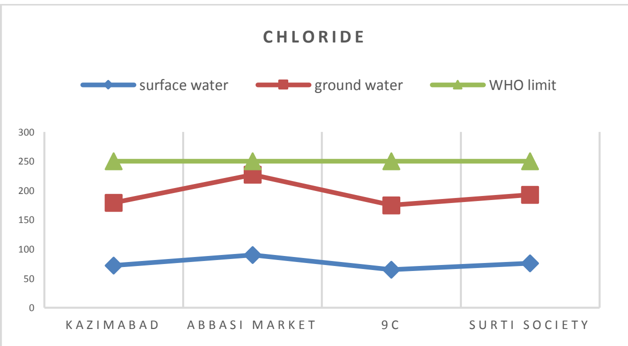

Figure 11: Chloride results comparison with WHO guidelines

The results show that the absorption of chloride in Model colony is low which is shown in table 9 and compared in Fig 11. The chlorides concentration depends on the water level when the water level decreases the chlorides concentration increases. They further observed that when level rises due to rain the consequent dilution decreases the chloride concentration.

4.10 Hardness (CaCO3)

The hardness of the natural water is mainly caused by the presence of carbonates, bicarbonates, sulfates and chlorides of calcium and magnesium.

Hardness is measure of polyvalent cations (ions with a charge greater than +1) in water. Hardness generally represents the concentration of calcium and magnesium ions because these are the most common polyvalent cations. The results are shown below in table 10 and are compared in Fig 12.

Table 10: Hardness results comparison with WHO guidelines

S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Hardness (CaCO3)	110 mg/L	472 mg/L	500 mg/L
2	Abbasi market		135 mg/L	473 mg/L	
3	9c		102 mg/L	450 mg/L	
4	Surti society		115 mg/L	435 mg/L	

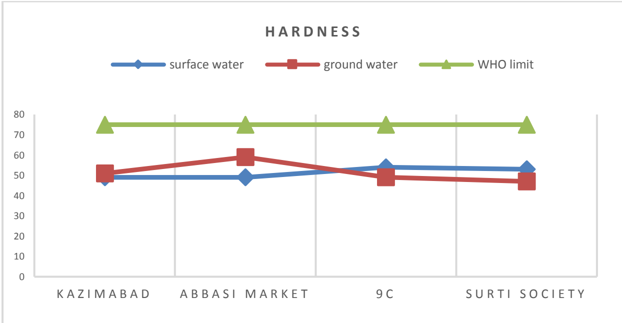

Figure 12: Hardness results comparison with WHO guidelines

4.11 Magnesium

Magnesium is a whit-silver malleable ductile metallic element. It can occur naturally in ground water and is often found in combination with ions. Magnesium level was found below than WHO guidelines. The analyzed results of magnesium are shown in table 11 and are compared in Fig 13.

Table 11: Magnesium results comparison with WHO guidelines

S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Magnesium	8 mg/L	15 mg/L	30 mg/L
2	Abbasi market		14 mg/L	19 mg/L	
3	9c		04 mg/L	15 mg/L	
4	Surti society		12 mg/L	17 mg/L	

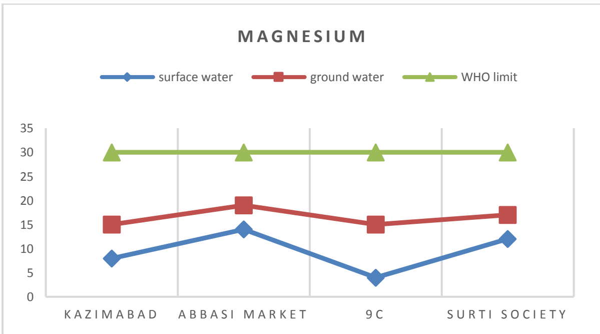

Figure 13: Magnesium results comparison with WHO guidelines

4.12 Nitrate

Nitrate (NO3) is highly soluble in water and easily transported in surface and ground water. Nitrates feed plankton aquatic plants and algae which are than eaten by fish. Nitrate (NO2) is relatively short lived in water because it is quickly converted to nitrate by bacteria. Excessive concentrations of nitrate/or nitrite can be harmful to humans and wildlife. The nitrate found in samples is low from WHO guidelines. The results are shown in table 12 and are compared in Fig 14.

Table 7: Nitrate results comparison with WHO guidelines					
S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Nitrate	0.34 mg/L	0.1 mg/L	10 mg/L
2	Abbasi market		0.15 mg/L	0.2 mg/L	
3	9c		0.34 mg/L	0.1 mg/L	
4	Surti society		0.30 mg/L	0.23 mg/L	

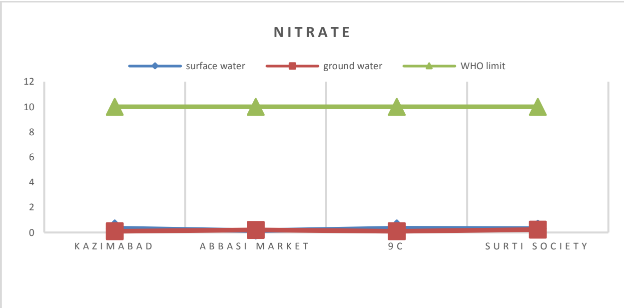

Figure 14: Nitrate results comparison with WHO guidelines

4.13 Potassium

Potassium is an essential element in humans and is seldom if ever found in drinking water at levels that could be a concern for healthy humans. It occurs widely in the environment including all natural waters. It can also occur in drinking water as a consequence of the use of potassium permanganate as an oxidant in water treatment. The analyzed results for potassium for given samples are shown in table 13 and are compared in Fig 15.

Table 8: Potassium results comparison with WHO guidelines					
S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Potassium	7.3 mg/L	4.5 mg/L	12 mg/L
2	Abbasi market		7.4 mg/L	5.3 mg/L	
3	9c		06 mg/L	3.4 mg/L	
4	Surti society		7.4 mg/L	7.43 mg/L	

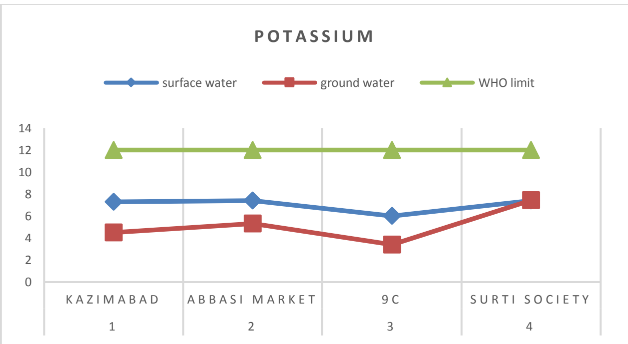

Figure 15: Potassium results comparison with WHO guidelines

4.14 Sodium

Sodium is resulting of surface and ground deposits of salts (e.g. sodium chloride) decomposition of sodium aluminium silicates and similar minerals. The sodium ion is the major constituent of natural waters. The sodium results found in samples are below from WHO guidelines, mentioned in table 14 and compared in Fig 16.

Table 9: Sodium results comparison with WHO guidelines					
S.No	location	Parameter	surface water	ground water	WHO limit
1	Kazimabad	Sodium	43 mg/L	80 mg/L	
2	Abbasi market		49 mg/L	76 mg/L	200 mg/L
3	9c		35 mg/L	59 mg/L	
4	Surti society		45 mg/L	73 mg/L	

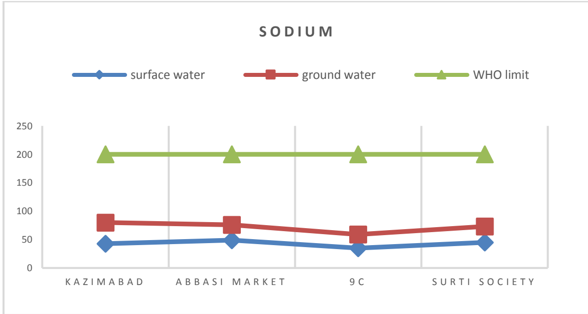

Figure 16: Sodium results comparison with WHO guidelines

4.15 Sulphate

Sulphate may be leached from the soil and is commonly found in most water supplies. Magnesium, potassium and sodium sulphate salts are all soluble in water.

Table 15: Sulphate results comparison with WHO guidelines					
S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	Sulphate	1 mg/L	1.5 mg/L	200 mg/L
2	Abbasi market		1 mg/L	1.5 mg/L	
3	9c		0.35 mg/L	0.52 mg/L	
4	Surti society		1.0 mg/L	1.8 mg/L	

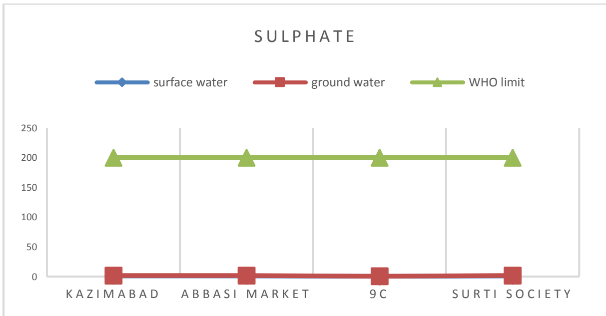

Figure 17: Sulphate results comparison with WHO guidelines

Calcium and barium sulphates are not very easily dissolved in water. There are several other sources of sulphate in water. Results of samples are given below in table 15 and are compared in Fig 17.

4.16 TDS

Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and some small amounts of organic matter that are dissolved in water. The water samples were analyzed and results were found below from WHO guidelines due to location is away from hilly areas. Results are given in table 16 and are compared in Fig 18.

Table 10: TDS results comparison with WHO guidelines					
S.No	location	parameter	surface water	ground water	WHO limit
1	Kazimabad	TDS	315 mg/L	770 mg/L	<1000 mg/L
2	Abbasi market		352 mg/L	748 mg/L	
3	9c		342 mg/L	650 mg/L	
4	Surti society		302 mg/L	702 mg/L	

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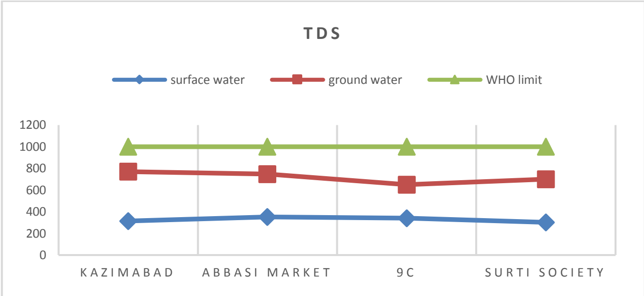

Figure 18: TDS results comparison with WHO guidelines

4.17 Fecal Coliform (E.coli)

E. coli is a type of fecal coliform bacteria commonly found in the intestines of animals and humans. E. coli is short for Escherichia coli. The presence of E. coli (and fecal coliforms) in water is a strong indication of recent sewage or animal waste contamination. The results of samples are given in table17 and are compared in Fig 19.

Table 11: Fecal Coliform (E.coli) results comparison with WHO guidelines

S.No	Location	parameter	surface water	ground water	WHO limit
1	Kazimabad		48 CFU	0 CFU	
2	Abbasi market	Fecal Coliform (E.coli)	46 CFU	0 CFU	0/250 ML
3	9c		28 CFU	0 CFU	
4	Surti society		35 CFU	0 CFU	

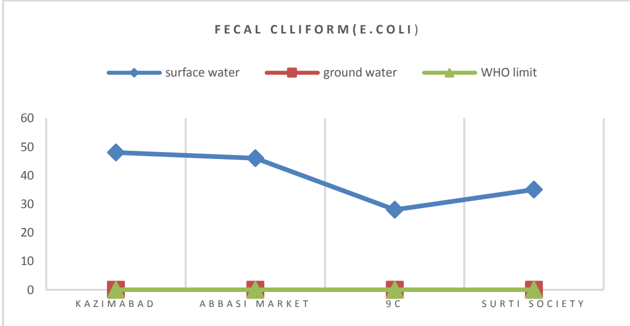

Figure 19: Fecal Coliform (E.coli) results comparison with WHO guidelines

5. Water Quality Index (WQI)

Weighted arithmetic index method of WQI is used to assess the quality of ground and surface water in Model Colony, Malir, Karachi

Table 18: Physico–chemical parameters determined in ground water of Model Colony

S.No.	Physical Parameters		Major Cations				Major Anions			
	pH	TDS	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3
	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	7.23	770	51	15	80	4.5	107	197	1.5	0.1
2	7.02	748	59	19	76	5.3	93	227	1.5	0.2
3	7.75	650	49	15	59	3.4	115	175	0.52	0.1
4	7.15	702	47	17	73	7.43	117	193	1.8	0.23
Mean	7.28	717.5	51.5	16.5	72	5.15	108	198	1.33	0.16
WHO Limit	8.5	1000	75	30	200	12	300	250	200	10

It is a simple method that aims at giving a single value to water quality by translating the list of parameters and their concentrations present in a sample into a single value. This single value in turn provides an extensive interpretation of the quality of water and its suitability for various purposes like drinking, irrigation, industrial etc.

Table 19: Physico–chemical parameters determined in surface water of Model Colony

S.No.	Physical Parameters		Major Cations				Major Anions			
	pH	TDS	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3
	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	7.69	315	49	8	43	7.3	82	72	1	0.34
2	7.49	352	49	14	49	7.4	60	90	1	0.15
3	7.35	342	54	4	35	6	78	65	0.35	0.34
4	7.35	302	53	12	45	7.4	50	76	1	0.30
Mean	7.47	327.75	51.25	9.5	43	7.02	67.5	75.75	0.84	0.28
WHO Limit	8.5	1000	75	30	200	12	300	250	200	10

First step for calculating WQI is to estimate the quality rating of each parameter using the formula: Qn=100*[(Vn – Vi) / (Vs – Vi)]. If quality rating Qn = 0 means complete absence of pollutants, while 0< Qn < 100 implies that, the pollutants are within the prescribed standard and when Qn >100 implies that, the pollutants are above the standards.

Table 20: Water Quality Index of collected ground water samples from Model Colony

Parameters	pH	TDS	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3
	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Observed Value (V_n)	7.28	717.5	51.5	16.5	72	5.15	108	198	1.33	0.16
WHO limits (V_s)	8.5	1000	75	30	200	12	300	250	200	10
Ideal value (V_i)	7	0	0	0	0	0	0	0	0	0
Q_n	18.66	71.75	68.66	55	36	42.92	36	79.2	0.66	1.6
$W_n = k / V_s$	0.321	0.0027	0.036	0.091	0.0136	0.227	0.009	0.0109	0.0136	0.273
$Q_n{*}W_n$	5.997	0.195	2.499	5.005	0.491	9.768	0.327	0.864	0.009	0.437
WQI= ∑ Qn Wn / ∑Wn = 25.60										

Second step is to calculate the unit weight (Wn) of all the physicochemical parameters with the help of formula: Wn = k / Vs, which is shown in Table 20 and Table 21. These unit–weights transformed all the concerned parameters of different units and dimensions to a common scale.

Calculated value of water quality index **(WQI= 25.60)** categorizes the ground water of Model Colony as **good** quality water which lies in the range of **25 - 50** as shown in Table 22. Weighted arithmetic index method of WQI reveal that the ground water of study area is not suitable for drinking purpose. However, it can be used for the domestic, irrigation and industrial purpose.

Table 21: Water Quality Index of collected surface water samples from Model Colony

Parameters	pH	TDS	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3
	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Observed Value (V_n)	7.47	327.7	51.25	9.5	43	7.02	67.5	75.75	0.84	0.28
WHO limits (V_s)	8.5	1000	75	30	200	12	300	250	200	10
Ideal value (V_i)	7	0	0	0	0	0	0	0	0	0
Q_n	28	32.77	68.33	31.67	21.5	58.5	22.5	30.3	0.42	2.8
$W_n = k / V_s$	0.321	0.0027	0.036	0.091	0.014	0.227	0.009	0.0109	0.014	0.273
$Q_n * W_n$	8.999	0.089	2.487	2.882	0.293	13.31	0.205	0.330	0.006	0.765
WQI= ∑ Qn Wn / ∑ Wn = 29.38										

Calculated value of water quality index (WQI= 29.38) categorizes the surface water of Model Colony as good quality water which lies in the range of 25 - 50 as shown in Table 22. Weighted arithmetic index method of WQI reveal that the ground water of study area is not suitable for drinking purpose. However, it can be used for the domestic, irrigation and industrial purpose.

Table 12: WQI range, status and possible usage of the water sample (Brown et al. 1972)

WQI	Status	Possible usages
0 – 25	Excellent	Drinking, Irrigation and Industrial
25 – 50	Good	Domestic, Irrigation and Industrial
51 -75	Fair	Irrigation and Industrial
76 – 100	Poor	Irrigation
101 -150	Very Poor	Restricted use for Irrigation
Above 150	Unfit for Drinking	Proper treatment required before use.

6. CONCLUSION AND SUGGESTIONS

Both the water sources (ground water and surface water) of Model Colony are not suitable for drinking purpose. It is concluded that some parameters like Lead and Fecal Coliform (E. coli) are found above from WHO guidelines, some like Arsenic, pH, Turbidity, Total Alkalinity as ($CaCO_3$), Calcium, Chloride, Hardness (CaCo3), Magnesium, Nitrate, Potassium, Sodium, Sulphate and TDS are found below from WHO guidelines. As regard of public opinion it is concluded that inhabitants are evolve in diarrhea, hepatitis-A, skin and Typhoid diseases and have negative impacts on ecosystem.

Calculated value of WQI revealed that the ground and surface water are unfit for drinking purpose but suitable for the domestic, irrigation and industrial use. The mixing of sewage water which may infiltrate from the river channels surrounding the study area, results in decreased quality of water.

For control of pollution at Model Colony an local government shuld take strong steps to control the pollution and to provide the awareness regarding negative impacts of contaminated water and its control strategies. It is suggested that water treatment plants approved by government must be provided at Model Colony to protect the life of habitant and aquatic life due to water contamination. Proper sewage systems and proper department for sewage system maintenance to avoid mixings of waste water in surface and ground water by over flowing of main holes and by infiltration of waste water because of leakage in pipes and due to other reasons. Awareness programs, seminars and trainings must be arranged at Model colony for public's knowledge and awareness and in order to minimize the liquid and solid waste.

Further it is advised that this study should be enhanced and frequently be made to determine the other metals and other remaining parameters as well as its impacts on health of residents.

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