Groundwater Quality Analysis for Human Consumption

A Case Study of Sukkur City, Pakistan

Abdul Nasir Laghari
Department of Chemical Engineering
Quaid-e-Awam University of Engineering, Science & Technology
Nawabshah, Pakistan
mashaalnasirlaghari@gmail.com

Zafar Ali Siyal
Department of Energy and Environment
Quaid-e-Awam University of Engineering, Science & Technology
Nawabshah, Pakistan

Daddan K. Bangwar
Department of Civil Engineering
Quaid-e-Awam University of Engineering, Science & Technology
Nawabshah, Pakistan

Mohsin Ali Soomro
Department of Civil Engineering
Quaid-e-Awam University of Engineering, Science & Technology
Nawabshah, Pakistan

Gordhan Walasai
Department of Mechanical Engineering
Quaid-e-Awam University of Engineering, Science & Technology
Nawabshah, Pakistan

Faheem Akhter Shaikh
Department of Chemical Engineering
Quaid-e-Awam University of Engineering, Science & Technology
Nawabshah, Pakistan

Abstract—**Drinking water quantity and quality is of the utmost importance. If the drinking water gets contaminated, it can result in severe health problems. For example, the continuous consumption of drinking water containing more than permissible amounts of fluoride can lead to bone deterioration and increased risk of bone fracture [1]. The present study was carried out to check the quality of underground water of Sukkur city. The analyzed parameters were fluoride, sodium, magnesium, calcium, potassium, iron, arsenic, TDS, pH, conductivity, odor, color and taste. World Health Organization (WHO) standards were followed in present study. Underground water samples were collected from 20 different populated locations of Sukkur city. Only arsenic, pH, iron and potassium were found to be within health safe limits while the rest of the parameters exceeded the permissible standards set out by WHO. The TDS, sodium, fluoride and magnesium were over the limits at some locations.**

Keywords-groundwater; water quality; physiochemical analysis

I. INTRODUCTION

Safe drinking water is the one of the core factors for a healthy life. Our two main water sources are underground and surface water. Only 3% of the underground water is fresh water and approximately 1.5 billion people use this water for drinking purpose [2]. In Pakistan, the average consumption of water is 1 gallon per day for drinking and 188 gallons for other purposes [3]. It is estimated that 17% of the world population is drinking water which is unsafe to drink, 32% consume from safe sources and the remaining 51% from centralized pipe supply systems [4]. In Pakistan, the unsafe quality of drinking water results in 30% of all diseases, 40% of all deaths and the majority of infant deaths. Many waterborne diseases are a direct result of polluted water consumption, like diarrhea, malaria, intestinal worms, anemia, cholera etc. [5]. Many of the leading causes of ground water contamination are industrial liquid waste, agrochemical disposal and untreated discharge of effluents [6]. There is unfortunately a lack of surveillance and monitoring programs to check the drinking water quality in Pakistan, a situations that gets worse considering the pathetic institutional and government arrangements, insufficiency of well-equipped laboratories, non-compliance of WHO standards and absence of a legal framework for drinking water quality problems [7]. Present study's purpose is to analyze the underground water quality of Sukkur city, compare the obtained results with WHO standards and put forward the measures need to be taken.

II. MATERIAL AND METHODS

A. Study Area and Sampling Locations

Sukkur city is situated on west bank of Indus River at latitudes 27°05' to 28°02'N and longitudes 68°47' to 69°43'E, altitude of 67m in Sindh Province. It is the 3rd largest city of Sindh and 14thof Pakistan. In this city, 60-80% of drinking water is taken from surface water. Figure 1 shows the map of Sukkur city, on which the sample locations are circled with red color and sample number, while the Table I shows location names.

B. Water Sample Collection

Around 20 water samples are taken from different sites of Sukkur city, particularly places from where people collect their drinking water. The standard method of sample collectionis that sample bottles are sterilized and collected in clean polyethylene bottles [8].

Fig. 1. Sampling locations

TABLE I. SAMPLING LOCATIONS

Sample No.	Detail of Locations
SPL1	Shahi Bazar Thalla Chowk
SPL2	Bandar Wall Road
SPL3	Old Sabzi Mandi, Ghanta Ghar
SPL4	Teer Chowk
SPL5	Barrage College
SPL6	City Point Military Road
SPL7	Bihar Colony
SPL8	Sheikh Muhala Ayoob Gate
SPL9	Old Sukkur
SPL10	Garibabad Beri Chowk
SPL11	Maki Masjid New Pind
SPL12	Adam Shah Colony
SPL13	Bachal Shah Colony
SPL14	New Goth Sukkur
SPL15	Makka Goth Shikarpur Road
SPL16	Food Storage Near Lu Biscuit Factory
SPL17	Main SabziMandi Shikarpur Road
SPL18	Sorath Society
SPL19	Society Near Kheer Thar Canal
SPL20	Jaferia Society

C. Parameters Tested

In present study, 12 water quality parameters were tested. They were as pH, TDS, fluoride, sodium, magnesium, calcium, potassium, iron, arsenic, conductivity, odor, color andtaste. All experimental work and tests were conducted according to standards and conducted at Energy & Environment Engineering Department, QUEST Nawabshah [9]. Table II lists the equipment used for this study.

III. RESULTS AND DISCUSSION

Table III shows the World Health Organization (WHO) standards for potable water suitable for human consumption. The study results are benchmarked against these standards.

A. pH

pHis the degree of acidity or basicity of an aqueous solution. The pH value ranges from 0 to 14 and 7 being neutral.pH less than 7 indicates acidity and greater than 7 indicates basicity [10]. The recommended pH value by the WHO for drinking water is from 6.5 to 8.5. Figure2 shows the acquired pH values of water samples at all locations. Location SPL13 has pH=7,8 which is the highest. This may be caused by the presence of toxic metals even at low concentration like copper and lead that are usually responsible for making the water alkaline. The use of agrochemicals, i.e., mostly plant nutrients and fertilizers, in the locality is responsible for the high concentration of heavy metals, which is definitely a major health risk. Such contaminations are possible to reach and retain in soil layers and may even percolate to the groundwater aquifers, thus inducing a greater human health risk [19]. Moreover, the geological structure of the catchment and buffering capacity also tends to influence the pH value of the water. The measured pH values of all the locations are within the WHO limits.

TABLE I. LIST OF EQUIPMENT USED

Apparatus Name	Model Number
Titration Apparatus	-
Calorimeter	DR 2800
Flame Photometer	420
Arsenic Kit	Econo Quick 481298
pH Meter	Model 215
TDS Meter	Model 651
EC Conductivity Meter	GMH 3430

TABLE II. WHO STANDARDS FOR POTABLE WATER

Parameter	Standard Value
pH	6.5-8.5
TDS	1000 mg/l
Sodium	200 mg/l
Fluoride	1.5 mg/l
Potassium	12 mg/l
Iron	0.3 mg/l
Magnesium	150 mg/l
Arsenic	50 mg/l
Calcium	200 mg/l

B. Total Dissolved Solids (TDS)

The measured values of TDS for samples of all the locations are presented in Figure3. The satisfactory value proposed by WHO is 1000 mg/L, while the measured values of TDS at 9 locations: SPL3, SPL7, SPL9, SPL10, SPL11, SPL14, SPL15, SPL17, SPL20 exceed the desired limit. The highest values are recorded at SPL14 and SPL15 and it is 6

times higher than the desired limit. Uncontrolled wastewater outflows both from domestic and industrial domains are the most possible reasons for high TDS values in the region, as certain portions of such flows are then percolate to the aquifers and polluting the groundwater. The TDS values exceeding the limits may affect the aesthetic water quality [11].

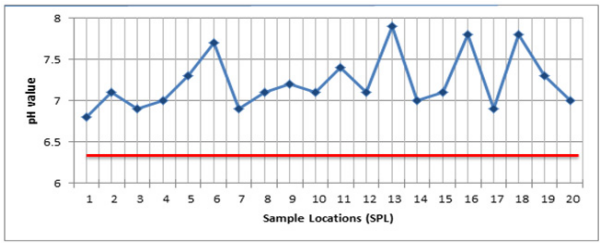

Fig. 2. pH results of 20 groundwater locations of Sukkur city

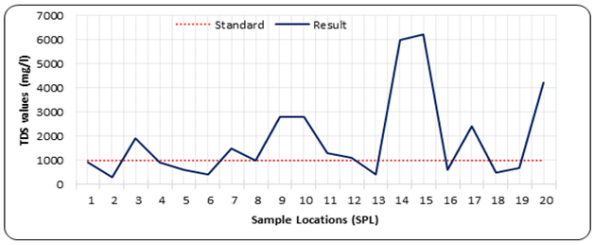

Fig. 3. TDS resultsof 20 groundwater locations of Sukkur city

C. Sodium

Measured values of Sodium for samples of all the locations are presented in Figure 4.Sodium is found higher than WHO standards in samples SPL10, SPL14, SPL15, SPL17 and SPL20. The excessive dose of sodium intake may cause nausea, dehydration, muscle twitching and vomiting. Effects of sodium overdose in infant may be different with gastrointestinal infection fluid loss, dehydration, neurological damage and hypernatremia [12].

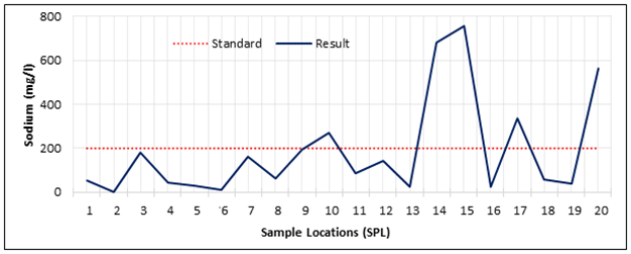

Fig. 4. Sodium results of 20 groundwater locations of Sukkur city

D. Fluoride

The measured Fluoride values for all locations are presented in Figure 5. Fluoride higher than the desired limit was found in sites SPL9, SPL14, SPL17, SPL18 and SPL20. This may be because of the abundance of phosphorite rocks in those areas as the fluoride in the water mostly comes from these rocks. The ground water at particular areas is not suitable for drinking purposes.Dental and skeletal fluorosis are health hazards relevant towater consumptionof higher fluoride concentration [13].

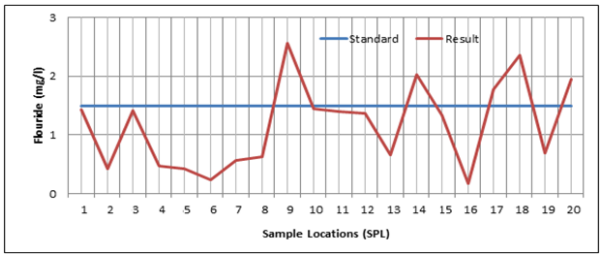

Fig. 5. Groundwater fluorideconcentration results of various sampling locations of Sukkur city

E. Potassium

All samples measured results for potassium are under the permissible limit regarding WHO guidelines and are presented in Figure 6. Such concentration of potassium in ground water could not have adverse effects for human health [14].

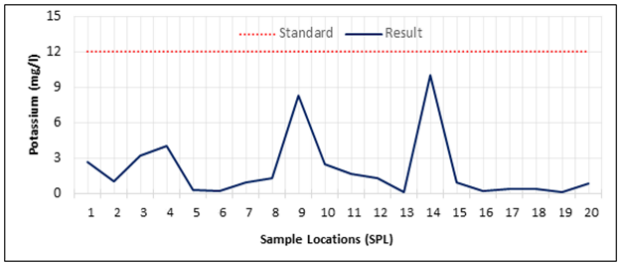

Fig. 6. Potassium results at various sampling locations

F. Iron

Measured iron values for all locations are presented in Figure 7 and they are found within the permissible limits of WHO standards, thus the consumption of underground water of Sukkur city is safe regarding this aspect [15].

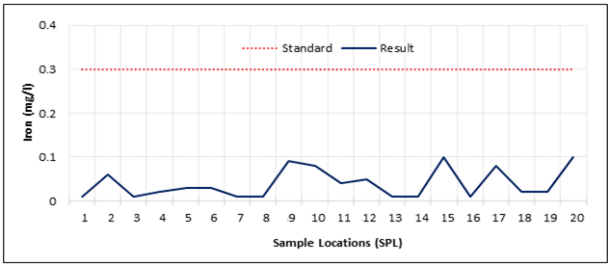

Fig. 7. Iron results at various sampling locations of Sukkur city

G. Magnesium

Measured values of magnesium are presented in Figure 8At three locations i.e. sample numbers SPL14, SPL15 and SPL20 magnesium is found higher than the desired limit. The excessive intake of magnesium may cause vomiting and diarrhea. High dose of magnesium in water may cause nerve problems, muscle slackening and depressions [16].

H. Arsenic

Measured results of Arsenic are presented in Figure 9 and were found to be within permissible limits of WHO guidelines [17]. Furthermore, no reports of lung bladder and skin cancer were found in the sampling premises, confirming that water is free from As.

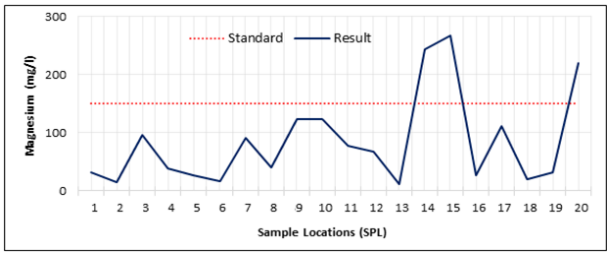

Fig. 8. Groundwater magnesium results of at various sampling locations

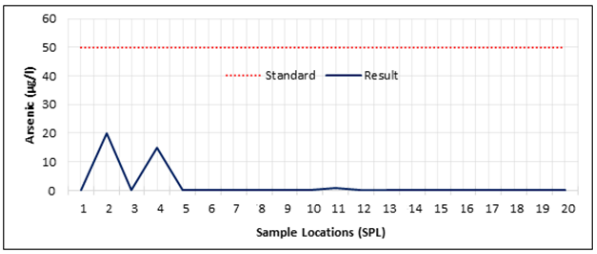

Fig. 9. Groundwaterarsenic results at various sampling locations

I. Calcium

The measured values of calcium for all locations are presented in Figure 10. The location majority has values within the desired limit but few locations exceeded it i.e. SPL2, SPL14, SPL15 and SPL20. Calcium determineswater hardness, inadequate calcium intake may cause increased risks of nephrolithiasis (kidney stones), osteoporosis, hypertension, coronary artery disease, and obesity [18].

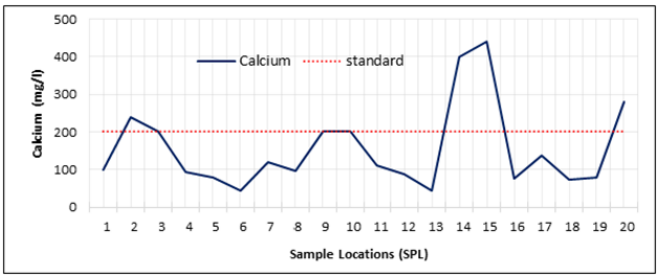

Fig. 10. Calcium results at various sampling locations of Sukkur city

J. Electrical Conductivity (EC)

Measured EC results are presented in Figure 11. It was observed that most of the EC values were beyond the permissible limit. Only five locations out of 20 showed satisfactory results. The exceeding values of EC indicate the sum of the cation (or anions), or in other terms, the total concentration of salts. High temperature may also be another possible reason for increased EC values, as the EC of solutions approximately increases 2 percent with increase in each °C of temperature.The unit of electrical conductivity is deci-Siemen per meter (dS/m). The higher EC may cause a gastrointestinal irritation in human beings.

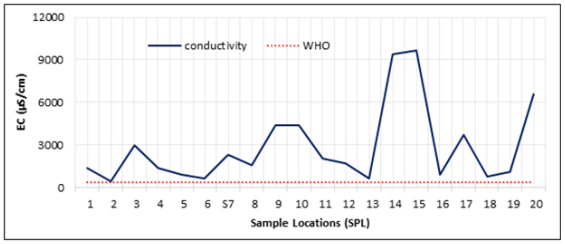

Fig. 11. EC of groundwater at various sampling locations of Sukkur city

IV. CONCLUSIONS

It was concluded that overall quality of underground water at most of the locations was quite satisfactory, since the results of many parameters of various locations were under permissible limits. Arsenic, pH, iron, potassium were within limits throughout all the locations while some parameters were exceeding the limits at various locations. TDS was higher at locations SPL3, SPL7, SPL9, SPL10, SPL14, SPL15, SPL17 and SPL20. Sodium was higher at locations SPL10, SPL14, SPL15, SPL17, and SPL20. Fluoride was higher at locations SPL9, SPL14, SPL17, SPL18 and SPL20. Magnesium was higher at locations SPL14, SPL15 and SPL20. Calcium was higher at locations SPL2, SPL14, SPL15 and SPL20. EC was higher at all locations except SPL2, SPL6, SPL13 and SPL16. Based on the results of this study, it is recommended that locations number SPL14 (New Goth Sukkur), SPL15 (Makka Goth Shikarpur Road) and SPL20 (Jaferia Society) must be examined thoroughly and possibly remedial measures must be taken into action.

ACKNOWLEDGMENT

Authors are thankful to the faculty of Energy & Environment Engineering Department for their assistance and support.

REFERENCES

[1] R. Buamah, C. A. Oduro, M. H. Sadik,"Fluoride removal from drinking water using regenerated aluminum oxide coated media", Journal of Environmental Chemical Engineering, Vol. 4, No. 1, pp. 250-258, 2016

[2] M. M. Mekonnen, A. Y. Hoekstra,"Four billion people facing severe water scarcity", Science Advances, Vol. 2, No. 2, e1500323, 2016

[3] M. T. Shah, J. Ara, S. Muhammad, S. Khan, S. Tariq, "Health risk assessment via surface water and sub-surface water consumption in the mafic and ultramafic terrain, Mohmand agency, northern Pakistan", Journal of Geochemical Exploration, Vol. 118, pp. 60-67, 2012

[4] M. L. Susko, M. S. Bloom, I. A. Neamtiu, A. A. Appleton, S. Surdu, C. Pop, E. F. Fitzgerald, D. Anastasiu, E. S. Gurzau,"Low-level arsenic exposure via drinking water consumption and female fecundity-A preliminary investigation", Environmental Research, Vol. 154, pp. 120-125, 2017

[5] S. Khan, M. Shahnaz, N. Jehan, S. Rehman, M. TahirShah, I. Din, "Drinking water quality and human health risk in Charsadda district, Pakistan", Journal of cleaner production, Vol. 60, pp. 93-101, 2013

[6] United States Environmental Protection Agency, Seminar Publication Wellhead Protection Guide for Small Communities, 1993

[7] A. Rasool, A. Farooqi, T. Xiao, S. Masood, M. AqeelKamran, S. Bibi, "Elevated levels of arsenic and trace metals in drinking water of Tehsil

Mailsi, Punjab, Pakistan", Journal of Geochemical Exploration, Vol. 169, pp. 89-99, 2016

[8] United States Environmental Protection Agency,Quick Guide To Drinking Water Sample Collection, available at https://www.epa.gov/region8-waterops/quick-guide-drinking-water-sample-collection.

[9] Pakistan Environmental Protection Agency, National Standards for Drinking Water Quality, 2008

[10] S. L. Gora, S. A. Andrews, "Adsorption of natural organic matter and disinfection byproduct precursors from surface water on TiO 2 Nanoparticles: pH effects, isotherm modelling and implications for using TiO 2 for drinking water treatment", Chemosphere, Vol. 174, pp. 363-370, 2017

[11] H. Y. Hu, Y. Du,Q. Y. Wu, X. Zhao, X. Tang, Z. Chen, "Differences in dissolved organic matter between reclaimed water source and drinking water source", Science of the Total Environment, Vol. 551-552, pp. 133-142, 2016

[12] W. H. Hallenbeck, G. R. Brenniman, R. J. Anderson, "High sodium in drinking water and its effect on blood pressure. (n.d.)", American Journal of Epidemiology, Vol. 114, No. 6, pp. 817-826, 1981

[13] L. Xu, G. Chen, C. Peng, H. Qiao, F. Ke, R. Hou, D. Li, H. Cai, X. Wan, "Adsorptive removal of fluoride from drinking water using porous starch loaded with common metal ions", Carbohydrate Polymers, Vol. 160, pp. 82-89, 2017

[14] World Health Organization, Potassium in drinking-water, available at: http://www.who.int/water_sanitation_health/water-quality/guidelines/chemicals/potassium-background.pdf, 2009

[15] World Health Organization, Iron in drinking-water, available at: http://www.who.int/water_sanitation_health/dwq/chemicals/iron.pdf, 2003

[16] World Health Organization, Calcium and magnesiumin drinking-water, available at: http://www.who.int/water_sanitation_health/publications/publication_9789241563550/en/, 2009

[17] P. Wongsasuluk, S. Chotpantarat, W. Siriwong, M. Robson,"Heavy metal contamination and human health risk assessment in drinking water from shallow groundwater wells in an agricultural area in Ubon Ratchathani province, Thailand", Environmental Geochemistry And Health, Vol. 36, No. 1, pp. 169-182, 2014