ORIGINAL ARTICLE

Physico-Chemical Assessment of Quality of Surface & Ground Water & its suitability for Drinking Purpose in Nawabshah City, Sindh, Pakistan

Abdul Jabbar Khandhro [*], *Atta Muhammad Chandio* [**], *Azam Hussain Yousfani* [***]

ABSTRACT

Objective: To determine the quality of surface and ground water and its suitability for drinking purpose in Nawabshah city, Sindh.

Study Design: Comparative, observational study.

Place & Duration: The work reports the analysis of groundwater and surface water samples collected from different towns of Nawabshah city during the period from 5th Dec, 2013 to 30th Jan, 2014.

Material and Methods: Sixty five groundwater and sixty surface water samples (water supply scheme) were collected from different parts of the Nawabshah city. Different physico-chemical parameters of water samples were measured at the field and in the laboratory. The conductivity, salinity and total dissolved solids (TDS) were measured with Orion 115 conductivity meter at the field. pH was recorded with Orion 420A pH meter. Total hardness, chloride and alkalinity were determined by titration with standard EDTA, silver nitrate and hydrochloric acid. Sulfate was determined by turbidimetry as $BaSO_4$ using Hitachi spectrophotometer. The metal ions Na, K, Ca and Mg were determined with Varian Spectr AA-20 atomic absorption spectrometer with standard burner head and air acetylene flame at conditions recommended by the manufacturer.

Results: The results of physical and chemical parameters of the water samples were varied in the following ranges. pH, electrical conductivity (EC), total dissolved salts (TDS) and concentration of essential metal ions Na, Ca, Mg and K. The results were varied within the ranges; pH 6.64-8.87, EC 240-10170 µS/cm and TDS 158-6050 mg/l, alkalinity 56-1225 mg/l, total hardness 84-1695 mg/l, chloride 32-1852 mg/l, sulfate 25-2170 mg/l. The concentration of essential metals was found in the ranges; Na 34-1725 mg/l, Ca 26-515 mg/l, Mg 13-430 mg/l, K 2-92 mg/l respectively. Presence of E.coli count ranged from 2-29/100 as most probable number index/100 ml (MPN 100/ml).

Conclusion: The analysis revealed that a number of ground water samples (70%) confirm their majority of parameters above the maximum permissible limits prescribed by WHO. Therefore the ground water of Nawabshah city may not be considered as safe to be used for drinking purpose. However, out of 60 samples only four surface water samples may be used for drinking purpose.

Keywords: Ground and Canal water, Water supply schemes, Physical & chemical proprieties, Coliform bacteria.

INTRODUCTION

The water in the Indus basin is of variable quality. It is not saline near sources of recharge, i.e. rivers and major canals but gradually becomes saline with depth as the distance from the recharge source increases[1]. Poor microbial quality of drinking-water is the most pressing issue. No urban water supply meets WHO drinking-water quality guidelines[3]. The major reasons for this are the intermittent supply through leaking pipes and cross connections with nearby sewerage lines.

People of the district mostly use underground water for drinking purpose, except some towns, where the water supply schemes provide surface water for drinking. The water we drink should meet some national and international standards. Chemical composition of surface and groundwater is one of the major factors to which the suitability of water for industrial, domestic and agricultural purpose depends[2]. The pollution of groundwater results from all the processes and reactions which the water faces from the moment it

* *Research Officer, Deptt. of Community Medicine PUMHSW, Nawabshah.*
** *Professor & Dean, Faculty of Community Health Sciences, PUMHSW, Nawabshah*
*** *Vice Chancellor, PUMHSW, Nawabshah*

Correspondence to:

Abdul Jabbar Kandhro
Research Officer,
Depatment of Community Medicine
PUMHSW, Nawabshah.
Cell: 0301-3586270

condensed in the atmosphere to the time it is discharged by a well or hand pump and varies from place to place with depth. Major portion of the rural inhabitants depends upon the groundwater due to unavailability of water treatment and supply of potable water. 40% of the deaths in Pakistan are caused by water borne diseases directly or indirectly[4]. A number of factors cause pollution of surface as well as groundwater including urbanization and industrialization. The quality of groundwater in Pakistan is deteriorating day by day. A serious problem appears due to stagnant management of effluent water which is penetrating into the soil with the passage of time and can become a part of natural and ground water[1,5-9]. A lot of work has been carried out on the quality of ground water of different parts of Pakistan but no any reasonable work is reported on the quality of underground water of Nawabshah city. The quality of water in domestic use must be tested to know the extent of its pollution and its suitability for human consumption. It is useful to examine the above highlighted problems in an environmental frame work in which the quantity and quality of water resources is a major concern. The object of this study is to assess the drinking water quality in various drinking water sources used in Nawabshah city.

MATERIAL & METHODS

Reagents

All the reagents used were of analytical grade and all the glass ware used was washed properly with double distilled water before use. The metal standard solutions were prepared by dilution from 1000 ppm stock solution of each metal.

Description of the sampling site

Study aimed to analyze the ground water and surface water of the Nawabshah city. 125 water samples were collected from different towns and union councils of Nawabshah city. Some water samples were also taken from water supply scheme of the Nawabshah city. Greater number of groundwater samples was collected from Nawabshah city. Different physico-chemical parameters of water samples were measured at the field and in the laboratory. The homogenized sample was transferred to a 1 L clean plastic bottle. The temperature of air on meter above the surface of water was recorded with mercury thermometer, conductivity, salinity and total dissolved solids (TDS) were measured with Orion 115 conductivity meter at the field. pH was recorded with Orion 420A pH meter. Hardness, chloride and alkalinity were determined by titration with standard EDTA, silver nitrate and hydrochloric acid respectively. Sulfate was determined by turbidimetry as $BaSO_4$ using double beam Hitachi 220 spectrophotometer[14].

The essential metal ions (Na, K, Ca and Mg) were determined with Varian Spectra AA-20 atomic absorption spectrometer with standard burner head and air acetylene flame. The analysis was carried out in triplicate with integration time 3 seconds and delay time 3 seconds. The concentration of metal ions (Na, K, Ca and Mg) was determined after appropriate dilution of the sample containing 1ml concentrated nitric acid per 250 ml. The SAR values were calculated using the formula, $SAR = Na/(Ca+Mg)\ 1/2/2$.

RESULTS

The work reports the analysis of groundwater and some surface water samples from Nawabshah city, located at the center of Sindh province. The results of physical and chemical parameters of the water samples were found in the following ranges. pH 6.64-8.87, EC 240-10170 µS/cm, TDS 158-6050 mg/L, chloride 32-1852mg/L, alkalinity-M 56-1225mg/L, hardness 84-1695 mg/L, SO4 25-2170 mg/L. The concentration of essential metal ions (Na, Ca, Mg and K) was found in the ranges of 34-1725 mg/L, 26-515mg/L, 13-430mg/L and 2-92mg/L respectively Table 1. For the confirmation of E.coli selective medium EMB was also used. Presence of E.coli count ranged from 2-29/100 as most probable number index/100ml (MPN 100/ml). Only four water samples were observed suitable for drinking purpose and remaining all the samples were highly contaminated with coliform bacteria. The results revealed that the majority of

ground water samples (40 out of 65) of the study area were not suitable to be used for drinking purpose; on the other hand, 40 water samples based on sodium adsorption ratio (SAR) were found suitable to be used for irrigation purpose.

DISCUSSION

In all the natural ecosystems water acts as the primary transport medium for dissolved and particulate matter and determines as well, the rate at which these fluids are added or removed from the system. A complete identification of hydrological characteristics is hence essential for understanding biological, chemical and physical processes that operate within the ecosystem.

The results of physico-chemical parameters of water samples reveal the varying nature of the underground water of the Nawabshah city. The difference in the quality of groundwater may be due to topography of soil; different earth beds and effect of recharge sources (canals etc) on underground water.

pH

The pH of water samples varied within the range 6.95-8.87. Sixty three samples confirm pH within the safe guidelines of 6.5-8.5 prescribed by WHO for drinking water, while only two samples were above the limits of WHO. These two samples were collected direct from Gajra (canal) running through Nawabshah city and from a hand pump located near to Gajra (canal). The high values of pH may be due to human activity (domestic and industrial waste) and water logging respectively. The waters with pH below 7.0 are termed as acidic and acidity in water is due to the presence of dissolved carbonic acid. It increases the solubility of different materials including metals ions like Na, K, Ca and Mg. Twenty samples indicated pH below 7.0 but indicated within the permissible limit of 6.5.

Total Dissolve Solids (TDS)

The TDS varied between within the range 158-6050 mg/L. A lot of variation was observed in TDS of water samples, only 10 samples were observed within the limits (500 mg/L) of WHO for drinking water. The variation in TDS may be due to different earth beds and recharge sources. Generally the water samples have high values of TDS making them unsuitable for drinking purpose. The water samples with elevated values of TDS may cause several health problems to living organisms and adversely affect the fertility of soil, if used for irrigation purpose.

Bicarbonates and Hardness

The contents of bicarbonate and hardness fluctuated varied between within the range 56-1225mg/L and 84-1695mg/L respectively. A parallel behavior of bicarbonate with hardness was noted. Hardness of 25 samples was within the safe limits prescribed by WHO for drinking water and six samples indicated their hardness above 700 mg/L may be due to geological reasons. The water with elevated hardness than the WHO guidelines may cause gastric problems, dehydration, gas trouble, kidney stone and heart problems[10].

Chloride and Sulfate

The concentration of chloride varied between within the range 32-1752 mg/L. Nearly half of the samples (35 samples) showed their chloride concentration above the regulations (250 mg/L) set by WHO. The chloride in water is present in combination with sodium, calcium and magnesium. Sources of chloride are mostly human waste, mineral rocks, irrigation discharge and industrial effluents like dying and bleaching materials. The water samples with higher concentration of chloride may have toxic effects to health.

The Sources of sulfate in surface and subsurface water are mainly calcium sulfate and sodium sulfate. The sulfates entering in water bodies come from dissolution of minerals containing sulfides and thiosulfates. Sulfate contributes to the permanent hardness to water. The elevated level of sulfate in water causes bad taste of water and also shows corrosive action[11]. Sulfate was found between 25- 2170 mg/L. Some of the water samples (20 samples) indicated their sulfate contents above the limits of WHO. These samples were collected from Kazi Ahmed road of

Nawabshah city. A parallel trend was found in the concentrations of chloride and sulfate in water samples[12].

The concentration of essential metal ions (Na, Ca, Mg and K) was varied between the ranges of 34-1725 mg/L, 26-515 mg/L, 13-430 mg/L and 2-92 mg/L respectively Table 2.

Table-1 Critical parameter exceeding the permissible limit

S.No.	Parameter	WHO Permissible limit	No. of sample exceeding permissible limit	Percentage of sample exceeding permissible limit
1	pH	6.5-8.5	3	4.62%
2	Conductivity	1500	49	75.38%
3	TDS	1000	42	64.62%
4	Total hardness	500	33	49.23%
5	Alkalinity	500	11	16.92%
6	Chloride	200	45	69.23%
7	Ca	100	47	72.31%
8	Mg	100	47	72.31%
9	Na	200	40	61.54%
10	K	12	33	50.77%
11	SO_4	500	28	43.08%

Table-2 Physicochemical analysis summary of groundwater samples in the study area

S.No.	Parameter	Unit	Maximum	Minimum	Average
1	pH		8.87	6.64	7.58
2	Conductivity	uS/cm	10530	361	3132.76
3	TDS	mg/L	5726	195	1751
4	Total hardness	mg/L	1480	144	517.80
5	Alkalinity	mg/L	1228	119	371.63
6	Chloride	mg/L	1752	84	451.10
7	Ca	mg/L	415	23	160.28
8	Mg	mg/L	485	15	101.80
9	Na	mg/L	1675	46	353.29
10	K	mg/L	94	2	21.92
11	SO_4	mg/L	2154	55	598.91

Table-3 Classification of water on the basis of total hardness

Total hardness mg/l	Type of water	No. samples
0 - 6 0	Soft	Nil
61-120	Moderate hard	6
121-180	Hard	16
>180	Very hard	45

Table-4 Classification of groundwater on the basis of Sodium absorption ratio

Parameter	Range	Water class	Samples	Samples
SAR	<6	Excellent	45	69.23%
	>6	Unsuitable	20	30.77%

Chemistry of Metal Elements The concentration of major metal ions Na, K, Ca, and Mg varied with high concentration of ground samples. The concentration of major metal ions follows following decreasing order:

Na > Ca > Mg > K

Sodium is present in all natural waters. The presence of sodium in water depends upon the anions present in that system and the temperature. The high concentration of sodium impart taste to the water and make it unfit for every day use and leads to cardiovascular diseases and high blood pressure[13]. Concentration of Na in water samples of the study area varied as 34-1725 mg/L. The Na ion concentration of the 25 samples was found with in the safe guidelines of 200 mg/L set by WHO for drinking water. All the rest of the samples indicated high values of Na ion concentration than WHO limits. Potassium plays an important role in the metabolism process of animals and, it is an important micronutrient for living organisms (plants and animals). The WHO threshold of potassium for drinking water is 12 mg/L. The potassium concentration of the water samples studied was varied between 2-92 mg/L, including 40 samples with K ion concentration within the permissible limits. Calcium and magnesium are abundant in rocks and soil, particularly lime stones and dolomites. They are relatively soluble and dissolve in surface water and then enter into ground water. There are no health concerns associated with calcium and magnesium, but the water containing these metals may contribute towards human dietary needs, however, their high concentration may cause scaling of pipes. The concentrations of Ca and Mg ions in the water samples of the area were found in the ranges of 26-515 mg/L and 13-430 mg/L respectively. Ca in 40 samples and Mg in 45 samples were found to be within the permissible limits of WHO. The rest of the water samples were observed very hard with high concentrations of Ca and Mg Table 3.

Sodium Adsorption Ratio (SAR)

Sodium adsorption ratio (SAR) was calculated to check the suitability of the waters to be used for irrigation purpose. The results revealed that determined 125 samples, only (60 surface water and 40 under groundwater) were suitable for irrigation with SAR value below 6 and remaining 25 samples were unsuitable for irrigation with SAR value above 6, all these 25 samples were under groundwater samples Table 4 (Fig-1).

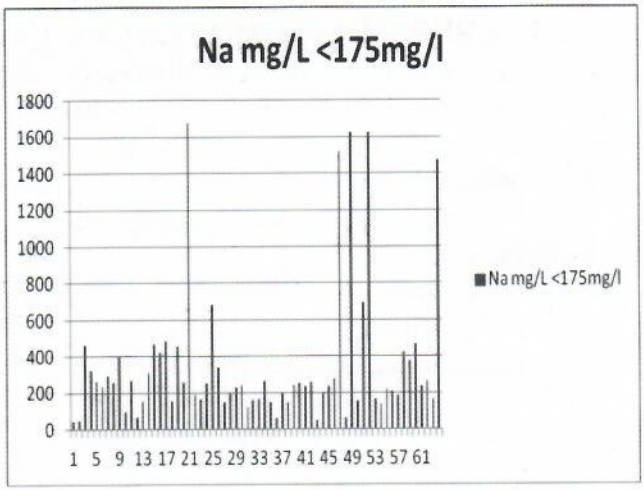

Figure-1. Graphical representation of Na ion concentration of water samples.

CONCLUSION

The analysis revealed that a number of ground water samples (70 %) showed their majority of parameters above the maximum permissible limits prescribed by WHO. Majority of the sites (all ground waters) were highly contaminated with toxic metals. The higher the concentrations of metals in ground water may be a concern for human health of Nawabshah city. Therefore the ground water of Nawabshah city may not be considered as safe to be used for drinking purpose. However, out of 60 water supply scheme samples, only 4 water samples may be used for drinking purpose and remaining all the water samples were contaminated with coliform bacteria. The common diseases gastroenteritis, diarrhea, vomiting, kidney, and skin problems may be linked with poor quality of water in this area.

Abreviations:

EC: Electrical Conductivity; TDS: Total Dissolved Solids; MPN: Most Probable Number; EDTA: Ethylene dinitrile- Tetraacetic Acid Disodium Salt; SAR: Sodium Absorption Ratio; WHO: World Health Organization

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