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RESEARCH PAPER

Groundwater quality assessment near Nullah Lai stream of Pakistan

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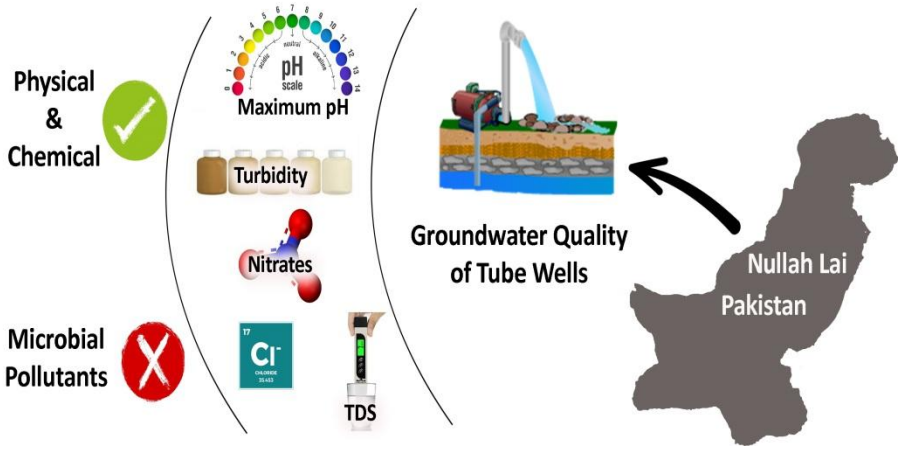
Highlights

- The evaluation of the groundwater quality performed in Nullah Lai basin in Pakistan.
- Different physcio-chemical and biological parameters on water quality based on importance in the subject area were studied.
- For physical and chemical parameters, water quality was within the limits of standards but very much contaminated with microbial pollutants.
- Nullah Lai stream can be pollution source for drinking water sources of the surrounding vicinity.

Graphical Abstract



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Abstract

This study was carried out to evaluate the groundwater quality of tube wells along the length of Nullah Lai, the main sewer line of the Federal area of Pakistan. Water samples from eight locations were taken from the nearby tube-well sources of the public water supply, and analyzed for the water quality parameters using standard procedures. About twelve different physcio-chemical and biological water quality parameters were studied, depending upon their importance in the subject area. The results obtained indicated that the water quality is within the limits of the available water quality standards in terms of physical and chemical parameters, but is very much contaminated with microbial pollutants, which needed to effective disinfection prior to drinking usage. The maximum pH, turbidity, TDS, Nitrates, Chloride, and Total Coliform recorded in the studied area was 8.2, 3 NTU, 645 mg/L, 9 mg/L, 362 mg/L, and 47 MPN/100 mL, respectively. The results of this study suggested that the drinking water sources of the surrounding vicinity were at greater risk in terms of pollution carried by the Nullah Lai stream in Pakistan.

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1. Introduction

In recent years, the growth of industry, technology, population, and water use has increased the stress upon both our land and water resources. Locally, the quality of groundwater has been degraded. Municipal and industrial wastes and chemical fertilizers, herbicides, and pesticides not properly contained have entered the soil, infiltrated some aquifers, and degraded the ground-water quality. Other pollution problems include sewer leakage, faulty septic-tank operation, and landfill leachates. In some coastal areas, intensive pumping of fresh groundwater has caused salt water to intrude into fresh-water aquifers (Afshari et al., 2011). In most of developing countries quality of drinking water has become a big hazard, reason for contaminated water is most of the time mixing of waste water to the potable water directly or indirectly. Leakages some time join the water supply lines; other reason is waste water infiltration to the groundwater thus contaminating groundwater quality. Environmental management of the wastewater is required to reduce the adverse impact on the drinking water aquifers for areas closer to the wastewater carriers (Faruqui, 2004; Strobl and Robillard, 2008). Moreover, from health perspective, it is advisable to minimize and prevent pollution, and address specific wastewater discharges. Reduce or eliminate the incompatible discharge of the liquid and solid waste to the streams and improve water quality. Water pollution has the effect on lives of many people throughout the world. For the evaluation of water pollution, water quality parameters are used for analytical purpose and also provision of safe drinking water to the citizens or public (Chaghakaboodi et al., 2021; Farokhian et al., 2021).

In developing countries, the mortality rate especially in the infants is very high. This is due to lack of monitoring facilities of water quality as well as improving facilities like treatment plants. In Pakistan, potable groundwater is available in general and is being utilized through tube-wells, hand pumps, infiltration galleries and open wells. In semi-hilly areas rainwater is stored and used for drinking purpose. In mountains, springs are the main source of water supply. The water supply system in most of the cities carries numerous injurious bacteria and other pollutants. Some of the contamination is due to the geological structure of the area bearing un-healthy minerals effecting the taste and characteristics of water. According to a WHO report, 40% deaths in developing countries occur due to water related diseases and in Pakistan; the critical value of water consumption of 1000 m^3/person/year has almost been reached, so the water quantity is not the only issue but water quality is also deteriorating. It is a sad fact that 17% of the global population lacked access to improved water sources, out of which nearly 2/3 living in Asia (Nejatijahromi et al., 2019). According to WHO report water borne diseases take the lives of over 10 million individuals per annum in the world. Further 75% of the diseases are due to use of unhygienic water in the developing countries. Humans have encountered obstacles in water management and, surprisingly, have not always solved the problem in favor of protecting our water supply (Hashmi et al., 2009; Haghshenas and Ghanbari Malidarreh, 2021).

The importance of groundwater in Pakistan can be observed from the fact that quantitatively water supplies are supplemented by groundwater. Groundwater in cities of developing countries is affected by the waste water carriers (Ashraf et al., 2011a; Ashraf et al., 2011b). Rawalpindi city contains the Nullah Lai as the waste water collector from the most of the city and also the neighboring upstream city Islamabad. Contamination of Nullah Lai water is due to disposal of industrial waste, household wastewater and field overflows contaminated with fertilizer and pesticides. All the waste water generated by the Islamabad city enters Nullah. So Nullah Lai has become the main wastewater carrier for the twin cities (Gadgil, 1998). It may affect the water quality of groundwater as it runs through the city and huge groundwater extractions are made at no of locations in the vicinity of the Nullah to fulfill the increasing demand of drinking water in the area. Somehow, municipal wastewater oxidizes and settles in the bed of the Nullah. Fines in the wastewater may percolate in the deep water even reaching groundwater and polluting groundwater aquifers (Ramteke et al., 1992). Impurities in the drinking water may cause many diseases in the residents and the water users (Mohammadizadeh and Ebadi, 2006). In recognition of the potential for pollution, biological and chemical analyses are made routinely on municipal water supplies. Since, the people usually identify the groundwater pollution when people start getting sick while drinking it, or when routine water quality monitoring reveals contamination. Therefore, this study was designed to evaluate the water quality of the adjoining residential areas and to suggests the possible

immediate the water treatment and wastewater management measures, on the basis of the analytical results obtained (Sabeen et al., 2020).

2. Materials and Methods

Fig. 1 shows the aerial view of Nullah Lai, and the location of various sampling points on it. The various sampling locations are designated as A, B, C, D, E, F, G and H, as mentioned in the Table 1. Sampling of the water quality along the length of Nullah Lai was conducted for a period of one year on regularly basis (Hu et al., 2005). These samples were then analyzed for the standard water quality parameters, using standard procedure as shown in Table 2.

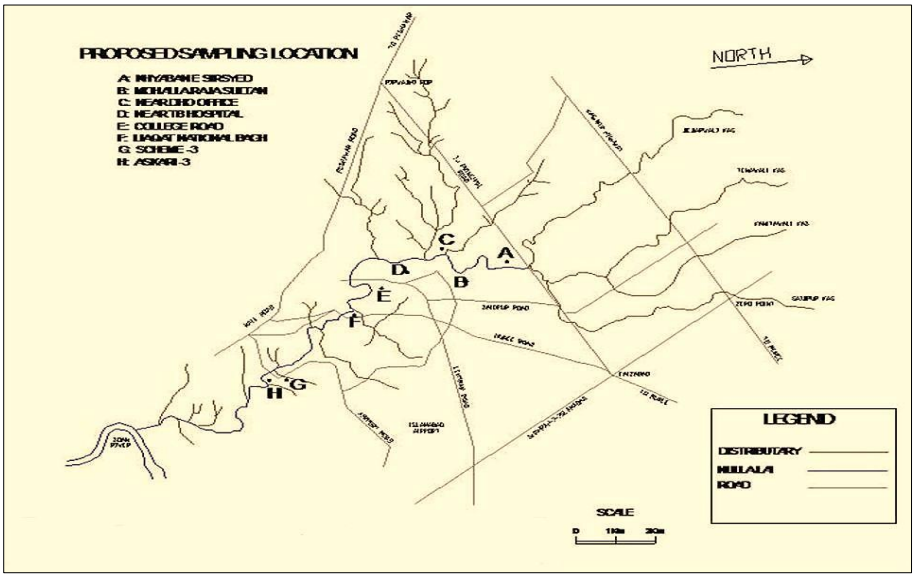

Fig. 1. Layout of Nullah Lai.

Table 1. Designated sampling points on Nullah Lai.

Sampling Point	Location on Nullah Lai
A	Khyabane Sirsyed
B	T/W 108A
C	T/W 165
D	T/W 145
E	T/W 64A
F	T/W 59
G	Scheme-3 T/W
H	Askari-3 T/W

Table 2. Water quality analysis techniques.

Parameter	Techniques
pH	pH meter
Turbidity	Nephelometric Method
Color	HACH Colorimeter
EC	Conductivity meter
TDS	Gravimetric technique
Nitrates	UV spectrophotometric screening method
Total Hardness	EDTA method
Chlorides	Argentometric method
Total coliform	Membrane filter technique
Fecal coliform	Membrane filter technique

3. Results and Discussion

The results of the study are illustrated in the Figs. 2-7 as shown. Refer to Fig. 2, the analysis shows that water samples have turbidity at all points .Highest level is observed at point "H" as 3NTU. It means that water quality is more deteriorated at this point as compared to other sides which may be due to the above mentioned causes. Moreover all samples have turbidity which shows that water is not fit for drinking, as highly turbid water is difficult to treat, thus such water has high level of contamination. The Fig. 3 of the study shows the pH concentration observed at various location of the subject area. The pH of the water samples ranged from 7.2 to 8.1. These pH values were within the permissible limits for drinking water as per WHO. However, the higher observed value of 8.2 at point "H" indicating the excessive growth of microbial contamination in the water. There is slight increase in the values of pH from point "A" to "H" which encourages the growth of algae, which in turn increases the amount of carbon dioxide, consumed and raises the pH level. Humans can increase this pH swing even more with the introduction of chemical pollution like fertilizers, which are added to water runoff in higher concentrations. The phosphates and nitrogen in these fertilizers create excessive algae growth, raising the water pH. Hence, this might be the reason of higher pH value at "H ."

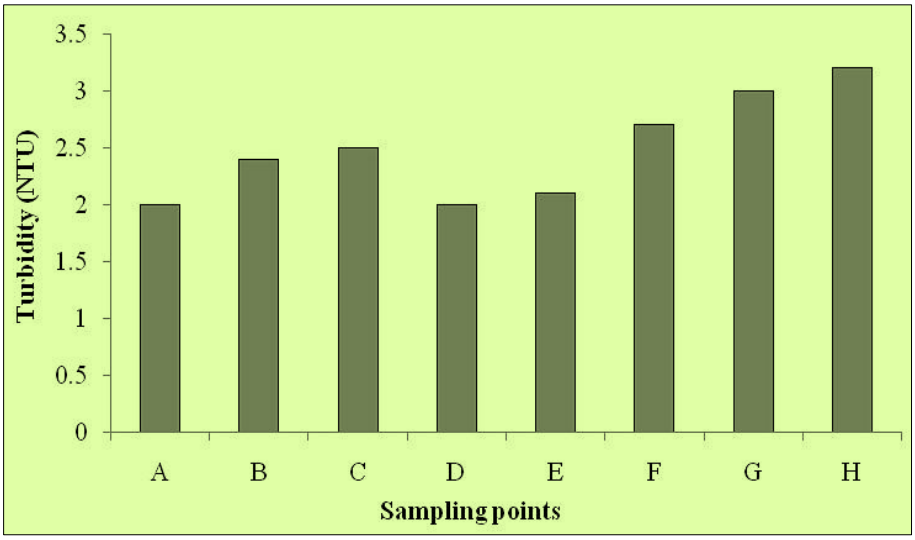

Fig. 2. Turbidity observed at different points.

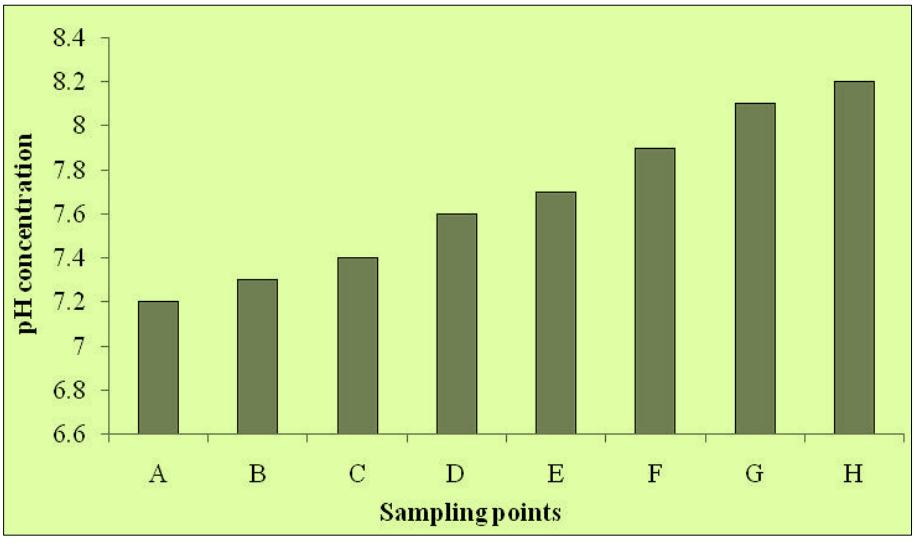

Fig. 3. pH value observed at different points.

As shown in Fig. 4, the concentration of TDS is within the WHO drinking water quality standards. The maximum observed value of TDS was 645 mg/L at point "H". The sample is taken from different sampling

points at Nullah lai and observation shows that the TDS values of sample goes on increase as we move ahead starting from lower point towards higher point. Similarly, The results shown in Fig. 5 indicates that the concentration of Nitrates in various samples ranges from 4-9 mg/L, and are also within permissible limits of WHO, i.e. 10 mg/L for drinking water.

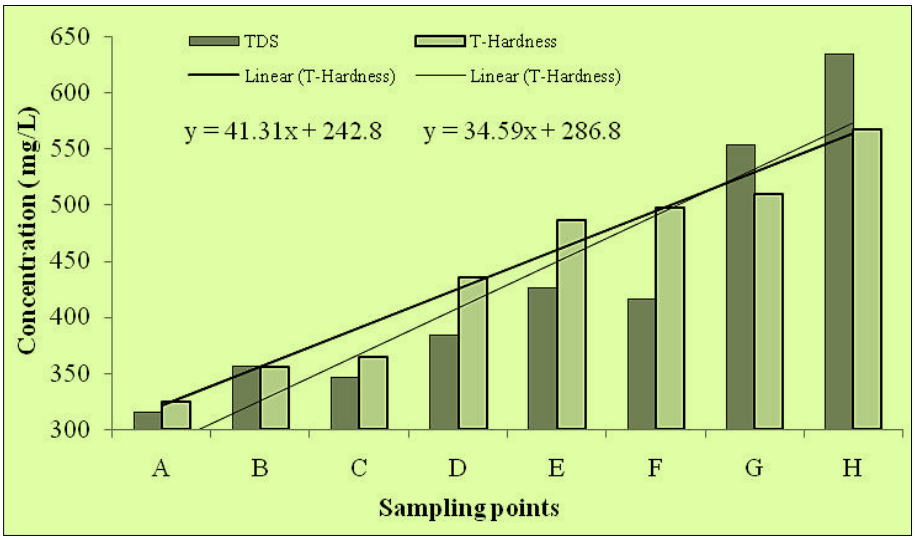

Fig. 4. TDS and hardness observed at different points.

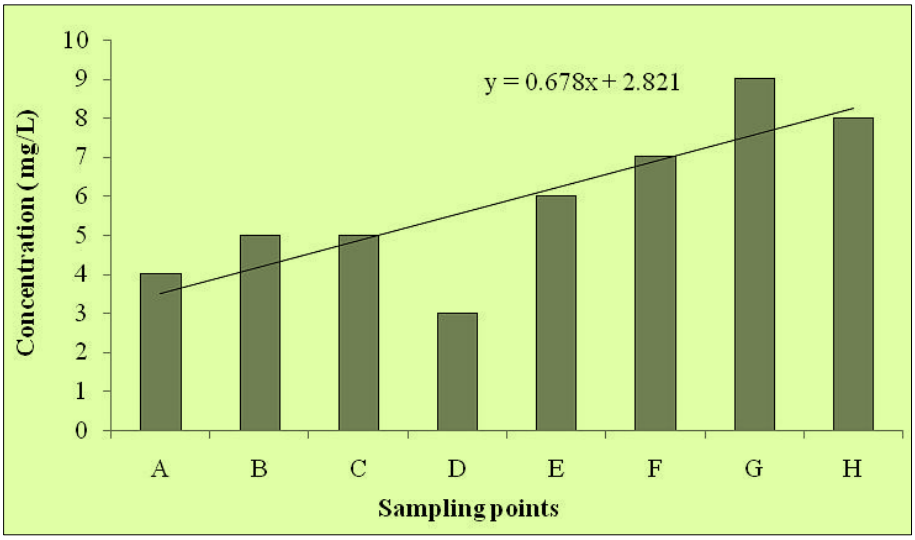

Fig. 5. Concentration of nitrates observed at different points.

WHO recommends the maximum concentration of 250 mg-chloride/L for drinking water sources? Water supplies having high concentrations of total dissolved solids (TDS) may also contain elevated chloride levels as part of the TDS. As much as 50% of the TDS may be due to chlorides. The high dose of chloride may result in detectable taste at 250 mg/L but no health-based guideline value is proposed. The results of the analysis show that the chloride concentration of the samples collected from point "A" and "B" are only within the WHO guidelines. The maximum value was observed at point "H", i.e. 365 mg/L (Fig. 6). The Fig. 7 is based on the observation made for the Total Coliform in the water samples. Almost, all the samples show some concentration of microbial contamination. The concentration of Total Coliform shows a gradual increase in from 7MPN/100 mL at point "A" to 49 MPN/100 mL at point "H".

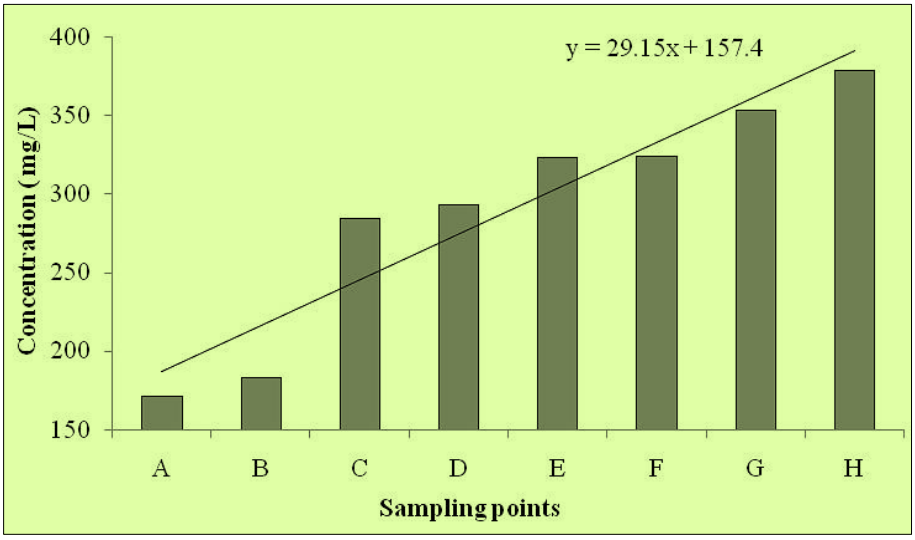

Fig. 6. Concentration of chlorides observed at different points.

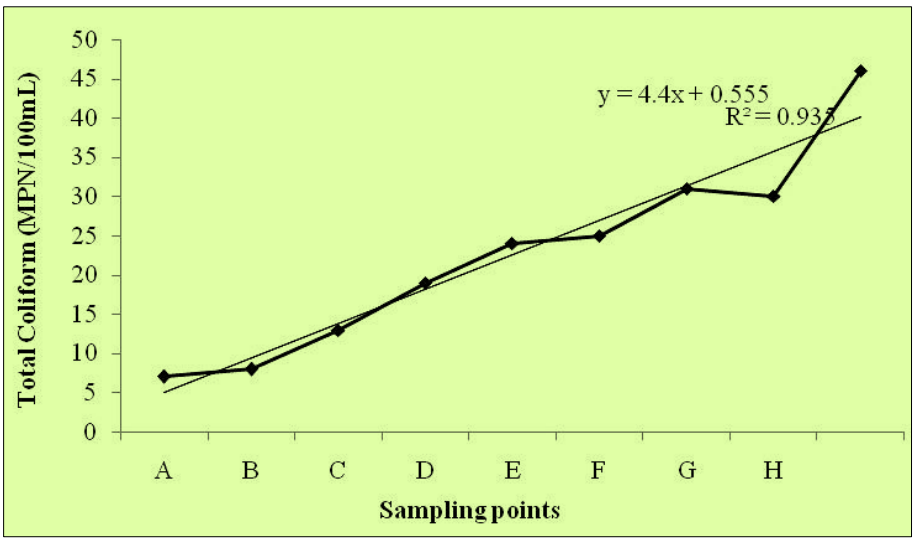

Fig. 7. Microbial contamination observed at different points.

4. Conclusion

The overall conclusions drawn from the present study, is that the Nullah Lai is a major treat to the drinking water sources of its surrounding area. The concentration of different pollutants goes on increasing as we more alone its length. There is a considerable increase in the concentration of TDS, Chlorides, Total Coliform, as we move along its length in the subject area. In the current status, these water sources require suitable water treatment before its final supply to the domestic consumers. Detail investigation of the water quality is required in the subject area, based on variety of physcio-chemical and biological parameters, especially the concentration of heavy metals is required to be evaluated. Furthermore, the detail soil investigation of the subject area is also required, to study the infiltration behaviour of the underground strata (Liang et al., 2020).

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