COMPARATIVE ANALYSIS OF HEAVY METALS CONTAMINANTS IN FRESH WATER AND WASTE WATER IN KILLA ABDULLAH REGION, BALOCHISTAN, PAKISTAN

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Abstract

Detecting heavy metals in both fresh and wastewater is really important for keeping our environment safe. If these metals are around, they can cause some major health problems like brain damage, kidney issues, and even raise cancer risks. In this study, we looked at levels of heavy metals like manganese, antimony, copper, chromium, sodium, lead, and iron in freshwater and wastewater from Killa Abdullah. So, in the Killa Abdullah area, we found that the average lead levels were 0.0009 mg/l in ground water, 0.0109 mg/l in surface water, 0.0200 mg/l in rain water, and 0.0023 mg/l in waste water. For iron, the averages came out to be 0.3223 mg/l for ground water, 0.0708 mg/l for surface water, 0.8261 mg/l for rain water, and 0.2663 mg/l for waste water. Then, looking at copper, we saw average values of 0.3500 mg/l for ground water, 0.100 mg/l for surface water, 0.3600 mg/l for rain water, and 0.0162 mg/l for waste water. When it comes to antimony, the averages were 1.6654 mg/l in ground water, 2.2205 mg/l in surface water, 0.5204 mg/l in rain water, and 1.5777 gm/l in waste water. Lastly, for manganese, the average levels were 0.1961 mg/l for ground water, 0.3152 mg/l for surface water, 0.3051 mg/l for rain water, and 0.2628 mg/l for waste water. There's definitely a mix of metals in the water, like iron, chromium, lead, antimony and copper. Looking at tube well water is kind of alarming because there are high levels of heavy metals. It seems like farming contributes to the chromium levels, while arsenic is more common near crowded areas and places with wastewater. This pretty much shows that we really need to get our act together on water management so we can lower health risks and ensure everyone has safe drinking water.

INTRODUCTION

The presence of heavy metals in water poses significant health risks, including potential damage to the kidneys, liver, and nervous system. Exposure to lead and mercury can adversely affect brain development, particularly in children. Prolonged consumption of contaminated water may elevate the risk of cancer and organ failure. Furthermore, heavy metals have the capacity to accumulate in the body over time, resulting in chronic toxic effects. In Balochistan the problem of water shortage with regard to irrigation is not only present but also has detrimental impact on the population of the area (Food and Agriculture organization [FAO], 2020). An alarming increase in the use of tube wells put pressure on this scarce resource in the case of the study area. The availability of tube well facilities has promoted the enhancement of drilling and has hazardous effects when it comes to recharge of the groundwater as many places experience steep drawdown of water levels in the aquifer (Khan et al., 2020).

In addition, such findings are more or less than capable of producing ecological consequences, and also have social and economic effects. Tap water pollution could result in severe adverse impacts to the health of the people especially to the rural populace who often use untreated water (Zafar et al., 2020). Prolonged metal toxicity causes diseases associated with the central nervous system, delayed development in kids, and several types of cancer (Hussain et al., 2019).

Not only is the agricultural sector of Balochistan to be endangered, it is also an important segment of the economy. Dirty water used to irrigate crops may leach and deposit heavy metals in the produce which is hazardous not only to human consumers but to the crops themselves (Raza et al., 2021). This leads to a process of destructive interaction between people and the environment, socio-economic problems that need to be solved (Naseem et al., 2022).

Due to these complex solvable tasks, it is necessary to find ways to prevent water pollution, using such an effective approach that can last for a long time. Use and promotion of appropriate water treatment procedures, improvement of existing approaches for irrigational purposes, and educating the public about the necessity of water preservation represent the measures necessary for protecting water sources in Balochistan. Also, coordination between the government agencies and non-government organization and local people can enhance the formulation of the policies other than emission control that focuses on the conservation of water quality and equal distribution of safe water (Khan et al., 2020).

Killa Abdullah is a district in Balochistan province, and its major environmental problem is the quality of the water in the area. When populations of people and the concentration of industrial inputs rise, the possibility of heavy metals posing a threat to both, fresh and wastewater systems, also rises. Several metals like lead, cadmium, arsenic and mercury has become major threats to the ecosystem and human beings because they bio accumulate in living organisms and find their way to the food chain Javed et al., 2021. The accurate regular checking and comparison of the heavy metal concentrations of various sources of water is vital of determining polluting agents and evaluating ecological impact (Ali et al., 2021).

Different sources of heavy metals include: industrial emissions, effluents from agricultural activities, and sewage. Waste management in Killa Abdullah is still in its infancy, and water pollution by waste materials makes it pertinent to determine the severity and type of pollution that exists in water bodies of the area. Comparison of the levels of heavy metals in fresh water and wastewater gives an understanding of the efficiency of the treatments conducted on wastewater and likelihood of heavy metal transfer to fresh natural water sources.

Samples of environmental matrices for heavy metals often contain complicated matrices That is why identification usually elicits the use of elaborate analytical methods. This approach like the Atomic Absorption Spectroscopy (AAS) can be interfered by the matrix effects due to other ions and also due to low concentration of heavy metals in these samples (Khan et al., 2021). To improve the performance of heavy metals, researchers use different pre-treatment and separation methods like solid phase extraction or ICP-MS which gives more selectivity and better detection limits than the methods described above (Zafar et al., 2020).

Comparative assessment of heavy metal concentration in fresh water and wastewater of Killa Abdullah is important for implementing the environmental standards and management strategies. It derived from this study goal to explain the level of contamination and provide useful information in the management of water resources in the region.

Heavy metal accumulation in the inland region is aggravating due to naturally occurring as well as anthropogenic activities with the Killa Abdullah region of Balochistan being affected most. As well as dissolved forms, heavy metals are often present in water as particles which can affect aqueous environments and, thereby, human capabilities as well. Several researches have pointed out that about 90 percent of the total concentration of heavy metals in water bodies, both surface and ground water, come from land based sources such as agriculture drainage and untreated industrial effluents. Open discharge of the raw wastewater and solid waste in Killa Abdullah water sources suggest that the following toxic metals are likely to build up in the environment.

It has been established that water is polluted by different heavy metals that also biomagnify in water animals such as crustaceans. This bioaccumulation very much affects these organisms and in one way or the other affects human beings through consumption of contaminated sea-food. Numerous shifts have shown high levels of heavy metals in crustaceans, then the implications of eating these creatures by human beings and other predate's (Javed et al., 2021). This remained inconclusive because, while heavy metals are necessary for metabolic functions at small concentrations and lethal at higher concentrations, assessment of risk, and safety remained a conundrum (Khan et al., 2021).

Investigation in for instance Killa Abdullah exposed that untreated waste is discharged to the environment and has been found to contain hazardous heavy metals including cadmium, lead, copper, zinc and nickel. Such practice is worrying especially knowing that only a small subset of these industries ever undertake simple recycling or even treatment of their waste before discharge. The constant inflows of suspending and settling heavy metals into the water sources are a source of concern for human and animal health as well as the resourceful aquatic ecosystem since the communities use the water for drinking, irrigation, and fishing.

Due to the complexity of heavy metal sources, characteristics and remediation in freshwater and wastewater, comparative determination of the heavy metal contamination in both types of sources in the Killa Abdullah region would be imperative to assess the level of pollution, the probable origin and methods of management. The objective of this study will be to give important information on the extent of heavy metal contamination in the water bodies of the region, and to support the ongoing initiatives towards trying to reduce the potential health effects and environmental effects resulting from heavy metal pollution.

Water deficit is a growing problem in Balochistan, especially because they mainly depend on the groundwater supply and poor water use. Prior research has noted a sharp decline in the availability of groundwater both from and as a result of tubewell drilling; the analysis shows excessive extraction of water as unsustainable (Ali et al., 2021; Khan et al., 2020). This over-reliance has an implication on the crop yield as well as on the local people especially the rural people due to increased competition for limited safe water resources (Shah et al., 2019).

Water pollution by heavy metals is a crucial problem all over the world of which numerous human activities have led to. Lead, arsenic, cadmium, chromium and other hazardous components have been identified to be present in Balochistan water particularly industrial discharges, run offs from agricultural fields and untreated sewage (Baloch et al., 2022). The build-up of these metals in waters poses severe environmental and health effects as they are fatalistic in the food chain (Javed et al., 2021).

Health effects of heavy metal toxicity are a well-known fact and continuous accumulation of heavy metals in the body causes severe validating syndromes, such as neurological disorders, developmental delay in children and various types of cancer (Khan et al., 2021). Reports have established that people that engage in the use of water that has not undergone treatment are most likely to be affected by these diseases and thus the need to enhance water quality management (Zafar et al., 2020). According to Hussain et al. (2019), daily surveillance of the content of such metal is crucial in order to preserve the health of the population of Balochistan and other areas affected by the problem.

Heavy metals pollution: The worst sector associated with water quality degradation in Balochistan is agriculture. Irrigation water contaminated with these metals can be taken up by crops and therefore easily reach the consumers as well as further compromise the sustainable production of food crops (Abdul et al., 2021). This results in an unending cycle of environmental problems and socio-economic problems leading to poor food security in the region (Naseem et al., 2022).

Protection of water bodies from heavy metal pollution hence requires good wastewater treatment. But poor WSHM practices in Balochistan lead to the regular discharge of untreated wastewater in natural water bodies (Baloch et al., 2022). According to Ahmed et al. (2021) a recent global survey shows that the extent to which industries are implementing basic recycling and treatment is negligible, and therefore a need to enhance wastewater management.

Policy interventions require collective approaches between governmental and non-governmental organizations and citizens in addressing WA and water quality (Khan et al., 2020). Public participation is therefore essential when it comes to the management of water resources as this increases the level of responsibility towards the manufacture of change towards water conservation (Shah, et al., 2019).

2. Research Methodology

2.1 Study Area

This study will be carried out in the Killa Abdullah region of Balochistan province, where there are multitudinous farming and dwelling tracts. This region has been chosen because this area is becoming sensitive to contamination with heavy metals resulting from anthropogenic influences.

Figure 1: Map of study area District Killa Abdullah, Balochistan.

2.2 Sample Collection

About five samples of water will be collected from within the Killa Abdullah region, both surface and wastewaters will be included. Sampling will be done during the spring rainy season in order to obtain a view to the conditions under which the samples are collected. Both site will provide us with samples of the surface water and groundwater and thus provide us with all the various heavy metals.

Figure 2: Collected Samples of water sources in District Killa Abdullah - (A) tubewell water from Habibzai, (B) spring water from Masezai karez, (C) wastewater from Shadar khan, and (D) rainwater collected in Gulistan.

2.3Sample Preparation

These samples will then be filtered so as to remove particles from the samples that are to be analyzed. From each sample collected subsamples will be retained for CNP analysis for and heavy metal analysis Sample handling and preparation will be done in accordance to standard procedure for reduction of contamination. The samples will be deposited in clean and labeled bottles and will be taken to the Hi-Tech Laboratory Department of Biochemistry at Balochistan University Quetta for the subsequent examination.

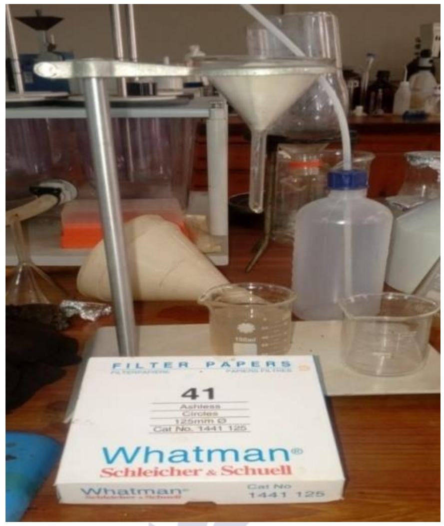

Figure 3: (Hi-Tech Laboratory Department of Biochemistry at Balochistan University Quetta).

2.4 Analytical Technique

The concentration of the heavy metals will be analyzed using atom absorption spectroscopy technique. Before analysis, calibration standards would have been made appropriately in an effort to increase accuracy. The following heavy metals will be targeted: are lead, cadmium, arsenic, copper, zinc and nickel.

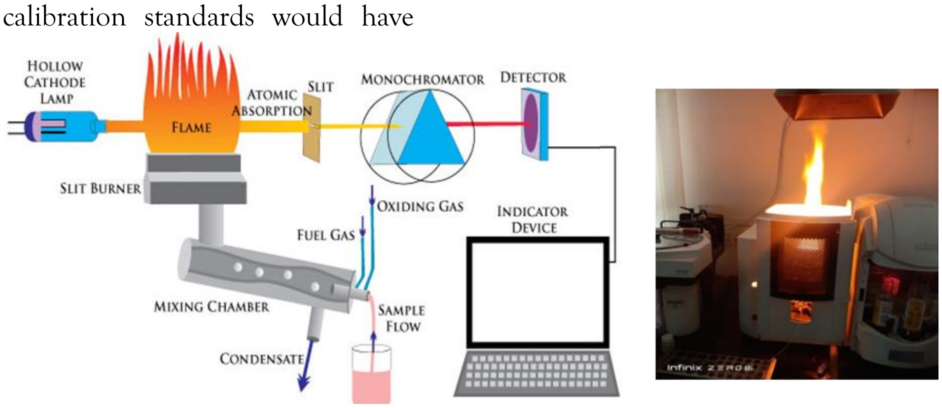

Figure 4: (AAS,Hi-Tech Laboratory Department of Biochemistry at Balochistan University Quetta).

So, for the first picture, you've got a diagram that breaks down how the AAS works to detect metals. Then, the second picture shows the actual AAS machine in action, with flames showing while it's analyzing samples.

2.5 Performance Assessment
The tramline performance characteristics of the AAS method will be determined by sensitivity, limit of detection, precision and accuracy. There will be an implementation of blank samples and certified reference materials for affirmation of the results.

2.6 Data Analysis
Collected data from the analysis will again be subjected to testing for statistical improvement in heavy metal concentrations with freshwater and wastewater sources. Mean, mode, median and frequency distribution will be employed in analyzing data while chi square test will be used in finding out differences.
The collected water samples will be analyzed in the Hi-Tech Laboratory Department of Biochemistry at Balochistan University Quetta for the determination of heavy metal concentration, pH will be measured by pH meter and conductivity will be measured by a mobile conductive meter.

2.7 Environmental and Health Risk Assessment
The research will also make an evaluation of the perceived ecological & health impact of the heavy metals pollution. These will include assessment of their tendency to bio magnify in water and the projected human risks within the region by ingestion of water and through the food chain.

2.8 Community Engagement
To increase the relevancy of the study, awareness programs will be conducted within the community to increase the community awareness of water quality and the health hazards pose by heavy metal intake. Sustainable water resource management will be promoted through partnership with local non-governmental organizations.
This work shall adopt research methodology which will facilitate the discovery of the nature and levels of heavy metal pollution in Killa Abdullah region which will be useful in implementing proper management and policy making.

3. RESULT
Total of (5) surface, ground, waste, and rain water samples collected from areas of district killa Abdullah, Balochistan were evaluated for the assessment of different heavy metals and different physical parameters by Atomic absorption spectrophotometer.

3.1 pH estimation in freshwater and groundwater
The average pH range 7 and 8.5 was observed in freshwater and wastewater respectively. The average pH of rain, surface, ground and wastewater from different area was 9, 7, 9, and 10 respectively in killa Abdullah.

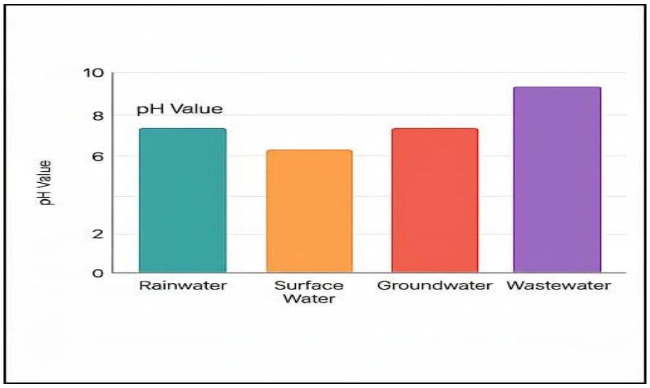

Figure 5: pH estimation in rainwater, surfacewater, groundwater, and wastewater.

3.2 Electrical Conductivity (EC) estimation
The average EC value of 65.84 – 118.45 us/ Cm and 60. 05 – 69.47 us/Cm was observed in freshwater and wastewater respectively.

3.3 Heavy Metal Detection
Total of 5 water samples were collected from different areas of District killa Abdullah, Balochistan in order to estimate the heavy metals concentration.

3.3.1 Lead (Pb)

The average **lead (Pb)** values from ground water, surface water, rain water, and waste water were recorded as 0.0009 mg/l, 0.0109 mg/l, 0.0200 mg/l and 0.0023 mg/l in killah Abdullah area respectively.

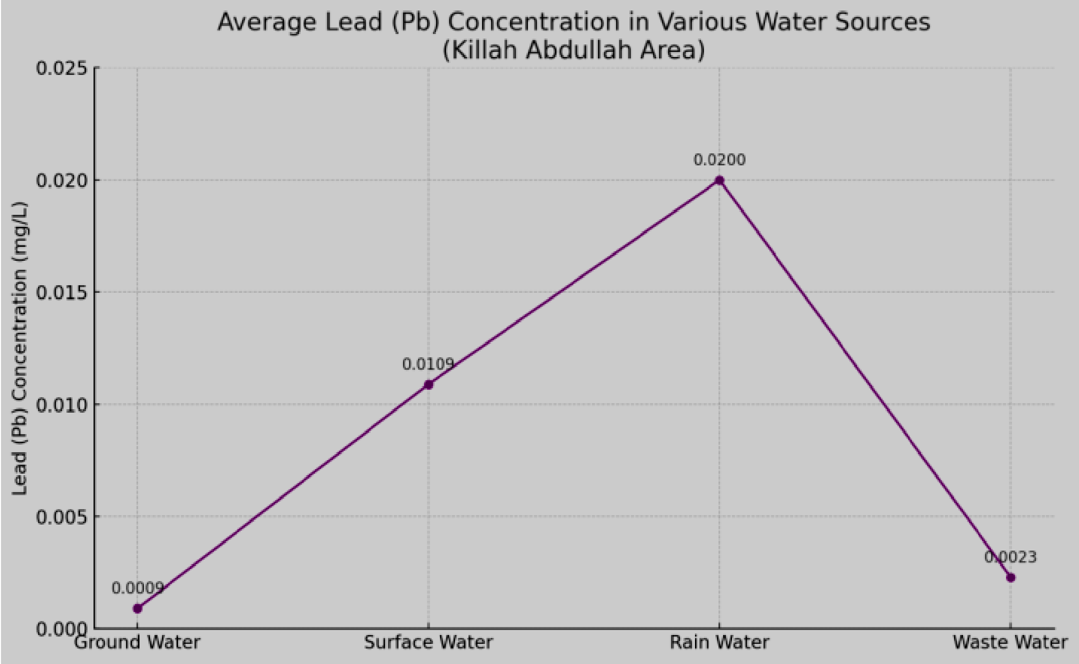

Figure 6: Lead (pb) in groundwater, surfacewater, rainwater and wastewater.

3.3.2 Iron (Fe)

The average **Iron (Fe)** value of ground water, surface water, rain water, and waste water were recorded as 0.3223 mg/l, 0.0708 mg/l, 0.8261 mg/l, and 0.2663 mg/l in killa Abdullah area respectively.

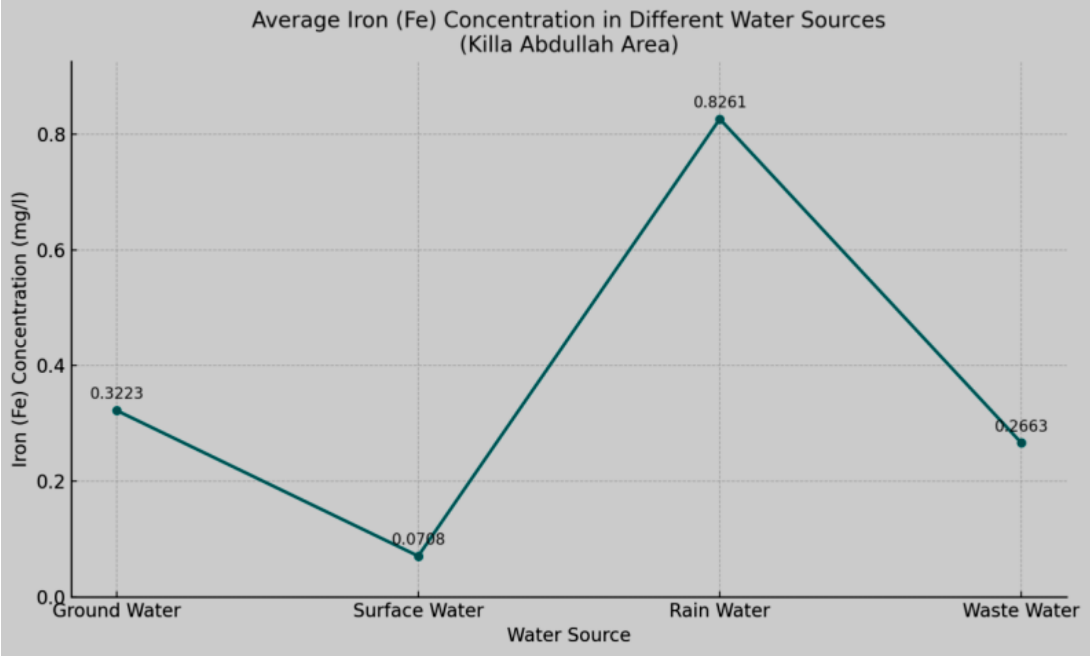

Figure 7: Iron (Fe) concentration in groundwater, surfacewater, rainwater and wastewater.

3.3.3 Copper (Cu)

The average **Copper (Cu)** value of ground water, surface water, rain water, and waste water were recorded as 0.35000 mg/l, 0.100 mg/l, 0.3600 mg/l and 0.0162 mg/l in killa Abdullah area respectively.

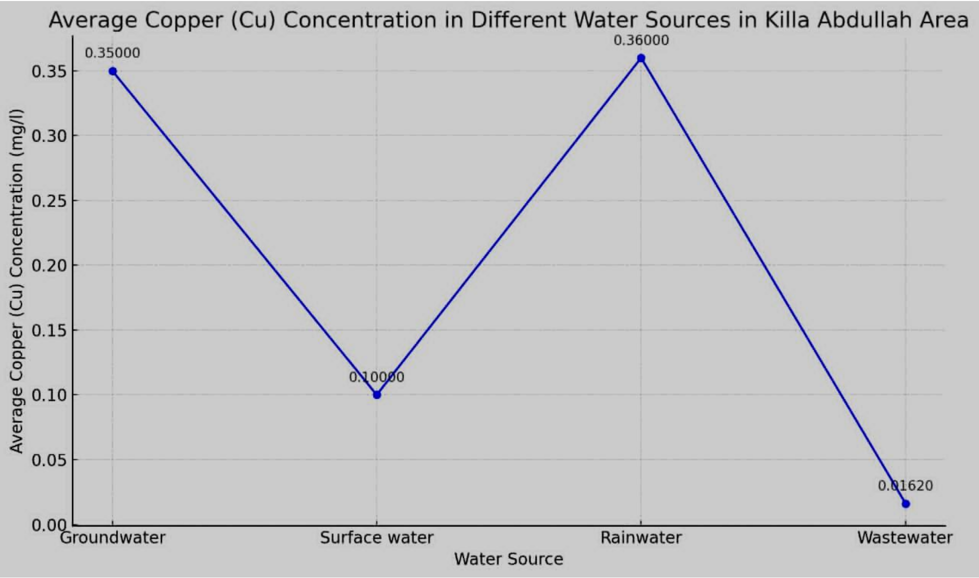

Figure 8: Copper (Cu) concentration in groundwater, surfacewater, rainwater and wastewater.

3.3.4 Antimony (Sb)

The average **Antimony (Sb)** value of ground water, surface water, rain water, and waste water were recorded as 1.6654 mg/l, 2.2205 mg/l, 0.5204 mg/l and 1.5777 gm/l in killa Abdullah area respectively

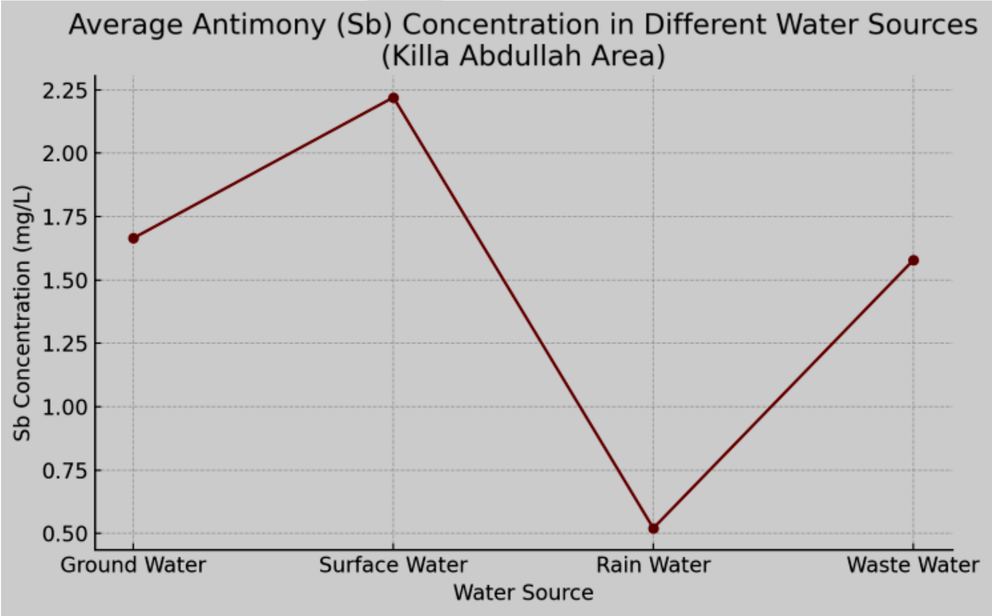

Figure 9: Antimony(Sb) concentration in groundwater, surfacewater, rainwater and wastewater.

3.3.5 Manganese (Mn)

The average **Manganese (Mn)** value of ground water, surface water, rain water, and waste water were recorded as 0.1961 mg/l, 0.3152 mg/l, 0.3051 mg/l and 0.2628 mg/l in killa Abdullah area respectively.

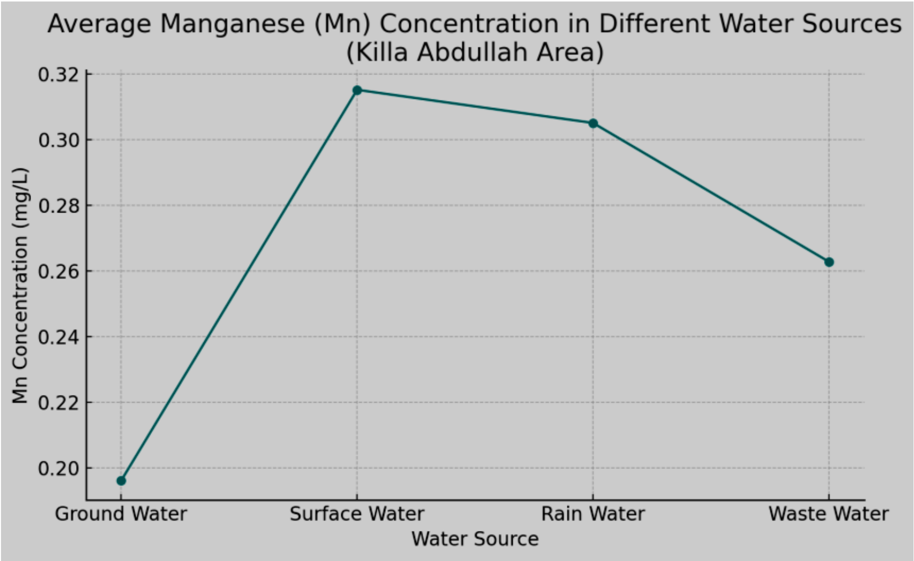

Figure 10: Manganese(Mn) concentration in groundwater, surfacewater, rainwater and wastewater.

Table: Heavy Metal Concentration (mg/L) in different water sources of Killa Abullah

Heavy Metal	Groundwater	Surfacewater	Rainwater	Wastewater
Lead (pb)	0.0009	0.0109	0.0200	0.0023
Iron (Fe)	0.3223	0.0708	0.8261	0.2663
Copper (Cu)	0.3500	0.1000	0.3600	0.0162
Antimony (Sb)	1.6654	2.2205	0.5204	1.5777
Manganese(Mn)	0.1961	0.3152	0.3051	0.2628

4. Discussion

Heavy metals and other quality parameters of ground, surface, rain and waste water samples collected from different sampling locations in District Killa Abdullah were studied. Five heavy metals namely: Cu, Mn, Sb, Fe and Pb, were identified using Atomic Absorption Spectroscopy (AAS)(American Public Health Association [APHA] et al., 2017). Besides, several physical parameters, namely, colour, appearance, transparency, EC, odour, pH, taste, and turbidity, were assessed to take an holistic approach to water quality (World Health Organization [WHO] et al., 2011).

The pH of the sources of water samples were different. Average pH of groundwater ranged from 6.96 to 8.8 and of surface water was 7.75-9.17. Surface water in particular had higher pH generally, up to a maximum of 9.17, as opposed to groundwater's maximum of 8.8. In the killa Abdullah area, a significant difference was observed, with groundwater having a pH of 6.96 and surface water registering 9.17. Other areas consistently showed pH values of 7 for groundwater and 8 for surface water (Khan, Ahmed, & Rehman et al., 2020).

Electrical conductivity (EC), a measure of the ionic strength of water, provides a quick estimate of electrolyte concentration. The average EC values were 66.48-119.54 µs/cm for groundwater and 59.86-70.48 µs/cm for surface water. All analyzed water samples exhibited EC values within the normal range for fresh water, which typically falls between 50-500 µs/cm(Hem, J.D et al., 1985; Sawyer, McCarty, & Parkin et al., 2003).

4.1 Conclusion

In this study the concentration of heavy metals was determined in water samples collected from different sources in District Killa Abdullah, such as ground water, surface water, rain water and waste water. The heavy metals explored were Copper (Cu), Manganese

(Mn), Antimony (Sb), Iron (Fe) and Lead (Pb). Results of these relationships were discussed on the basis of local factors like position, pH, EC and possibilities of human activities such as agricultural activities.

An interesting result was the absence of extremely toxic As (Arsenic) in all thecollected water samples of groundwater, surface water, rainwater and wastewater in all tehsils of District Killa Abdullah; this is a positive sign of the water safety in the area for this heavy metal.

General physical parameters such as pH and electrical conductivity was not found to have a significant linear relationship with the presence of these heavy metals as revealed by the study. application of chemicals In agriculture, especially pesticides and formulation and spraying of chemicals on watersheds cannot be neglected.Where there are a lot of orchards, it seems that heavy metals like chromium might be more common. This comes from past studies in similar farming areas, although we didn't measure it with the new data. You can also find Copper, Manganese, Antimony, Iron, and Lead in ground, surface, rain, and wastewater. This suggests that both natural geology and human activities could be causing the pollution.

So, it looks like the geology in District Killa Abdullah, along with how farmers use things like fertilizers and pesticides, really plays a big role in how much heavy metal is in the water there. Plus, the depth of tube wells might be a factor too, based on what we've seen in other studies. It'd be a good idea to keep an eye on this and do more in-depth studies to make sure the water stays safe and clean for the long run.

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