Paper No.174

IMPACT ASSESSMENT OF DOMESTIC AND INDUSTRIAL EFFLUENT ON GROUND WATER QUALITY SURROUNDING LAHORE. A COMPARATIVE STUDY OF HIGH AND LOW FLOW SEASON

Munawar Ahmad,
Dhanji Mal,
Maimunah Shabbir,
Muhammad Mumtaz

IMPACT ASSESSMENT OF DOMESTIC AND INDUSTRIAL EFFLUENT ON GROUND WATER QUALITY SURROUNDING LAHORE. A COMPARATIVE STUDY OF HIGH AND LOW FLOW SEASON

Munawwar Ahmad[1], Dhanji Mal[2], Maimunah Shabbir[3], Muhammad Mumtaz[4]

ABSTRACT

Lahore is the second most populous city of Pakistan and the 32nd most populous city in the World. Lahore is located in the north-eastern end of Pakistan's Punjab province. As population is increasing at alarming rate, the demands of water, foods and fibers is also increasing. Further, population growth is not only overburden on groundwater resources but also contributes to groundwater and surface water contaminations through domestic and industrial waste and ultimately it is discharged into rivers nearby city. There are two large and 11 small industries clusters having 1213 units of different type of industries. Collectively generate huge quantity of 4.85 Million cubic meter waste into Ravi River on daily basis through different drains. This study was carried out to analyze impact of domestic and industrial waste on ground water quality nearby Lahore. Elevation samples nearby different drains locations were collected and analyzed from PCSIR Lab for both low and high flow seasons. Results reveals that three parameters includes chlorides, Sulphate (sulfate), and pH of all samples found within National Environmental Quality Standards (NEQs) permissible limits. Similarly, four water quality parameters include arsenic, magnesium, total plates counts, and faecal coliforms of all samples were found in exceeding permissible limits. Further, concentrations of calcium also exceeds in all samples for both seasons except one of the sample at shallow depth at Mehmood Booti site. Concentrations of total hardness as well as total dissolved solids is higher in case of high flow seasons as compared to low flow season. Therefore, it can be concluded that the groundwater quality is not fit for drinking purpose. Therefore, it is recommended to use boiled water since most of the samples have higher concentration of calcium and magnesium. Samples contain microbiological contaminations. It is recommended that groundwater sources should be protected so that animal /human waste don't mix in the groundwater. Furthermore, Industrial waste should be treated before discharging into drains/ River. So that it does not contaminate ground water of nearby drains and areas surrounding River. Recharge wells should be installed at different locations in urban areas for recharging groundwater through rain water.

Keywords: Ground water**,** water quality parameters, pollution.

[1] Munawar Ahmed, Director General, IWASRI, WAPDA, Lahore. Email: munawar_arain2006@hotmail.com, 03003071796.

[2] Dhanji Mal, Junior Engineer (Civil), IWASRI, WAPDA, Lahore. Email: engrdhanji@gmail.com, 03322637506.

[3] Maimunah Shabbir, Junior Engineer (Civil), IWASRI, WAPDA, Lahore. Email: Maimunahshabbir@gmail.com, 03224723739

[4] Muhammad Mumtaz, Senior Engineer (Agri), IWASRI, WAPDA, Lahore. Email: Engrmmumtaz21@gmail.com, 03006351112

1. INTRODUCTION

In the history of mankind, natural water resources have almost always been the mainspring of civilization. Being an indispensable resource, human civilization engineered methods to harvest, store and utilize water. In addition, water bodies have served as reservoirs to dump waste material, mainly owing to the concept that flowing water will replenish itself downstream by dilution. Accordingly, there has been ruthless and unchecked discharge of waste material into natural water bodies. Exponential booming of human population has further exacerbated the stress on water resources, causing a reduction in their capability to dispose waste material merely by dilution. But there is no more downstream. Consequently, water pollution has emerged as one of the toughest challenges for the survival of mankind. The growing ecosystem degradation around the world is particularly more damaging to vast population of poor developing countries like Pakistan. Pakistan economy holds a double-edged sword of economic growth and ecosystem collapse. Process complexities, high energy consumption, lack of highly skilled operators, and high capital and operational costs have made the conventional treatment methods difficult to adopt in these countries. The River Ravi is one of the three Western rivers of the Indus Basin whose waters were allocated to India under the Indus Waters treaty, 1960.Since the early 21st Century, the development of irrigation and water infrastructure in India has meant that little or no water flows across the Indo-Pak border in the River Ravi. Unfortunately, the banks of the River Ravi along Lahore are used for the discharge of untreated domestic and industrial wastewater and effluent. There are over a dozen disposal stations and two surface water drains that discharge untreated wastewater into the river. The levels of impurities in the water are in excess of National Environmental Quality Standards set by the Pakistan Environment Protection Council and enforced by the Environment Protection Agency, Punjab (the EPA, Punjab).The scale of this discharge is enormous. It is calculated that nearly 48% of the overall pollution discharged into the River Indus comes from the River Ravi. At this point in time, the River Ravi is no more a river but a sludge carrier. The environmental impacts of this discharge are also enormous. Not only is the water flowing in the River Ravi unfit for human consumption, but the toxic industrial effluents that flow into it make is unfit for recreational purposes too. The pollution has led to the extinction of some 42 species of fish that inhabited the river as it flowed past the city and has meant that a natural habitat for birds and animals has been destroyed and they have been forced to migrate elsewhere. The wastewater discharged into the River Ravi at Lahore flows to the irrigation headwork at Balloki and is then used to irrigate parts of Southern Punjab. The pollutants in the water mean that it is unsafe for drinking purposes. The research of water quality shows that a high metal content in the water makes it susceptible to soil leeching, which means that many crops grown with this irrigation water are also contaminated. The health impacts of this pollution are staggering. UNICEF estimates that 20-40 percent of Pakistanis in hospitals today are there because of waterborne disease. The death rate amongst children due to impure water is extremely high, suggesting their vulnerability to the effects of pollution. The literal

meaning of the word pollution is 'destruction of purity'. In a broader sense, water pollution refers to any undesirable change in the composition and/or temperature of natural water resources that renders them inappropriate for best usage. Health risks related to water quality, primarily due to, domestic, industrial wastewater and agrochemicals, represent a growing problem. This is mainly due to the untreated sewerage water and industrial waste and intensified production and the expansion of irrigated agriculture, often in association with food processing industries. This research study is carried out to assess the impact of domestic and industrial effluents on groundwater quality during low and high flow seasons surrounding Lahore.

2. LITERATURE REVIEW

2.1. Wastewater in Lahore

Lahore is the capital city of the Pakistani province of Punjab. It is the 2nd most populous city in Pakistan and the 32nd most populous city in the world. The city is located in the north-eastern end of Pakistan's Punjab province, near the border with the Indian state of Punjab. Lahore is one of Pakistan's wealthiest cities with an estimated GDP of $58.14 billion (PPP) as of 2014.There are two designated industrial estates (Quaid-e-Azam Industrial Estate and Sunder Industrial Estate) and same number of small industrial estates (Katcha Jail road and Sundar-Raiwind road). There are 11 industrial clusters including the one along Hudiara Drain, Charar Drain, Kattar Bund Road and Ferozepur Road from Attari to Kasur boundary, Multan Road from Thokar to Manga Mandi, Raiwind Road, Raiwind-Manga Road, Lakhodair, Behni Road, and Ring Road from Ravi Bridge to Mehmood Booti. Out of 1213 units, 413 are steel industries, 254 textile, 113 engineering, 60 plastic, 51 warehouses, 45 pyrolysis plants, 39 paper, 38 food, 30 pharmaceutical, 23 brick kiln, 20 each rice mills, 19 each stone grinding, paint and chemical, 14 electrical appliances, 11 carpets, 8 rubber, 7 ghee and oil, 6 each pesticides, foam, leather tanneries and asphalt plants, 5 synthetic leather, 4 each aluminum, flour and ice, 3 glass and 2 each fertilizers and chip board. Collectively industrial wastewater of 4,847,040 m^3/day is discharged into the Ravi River through seven surface drains including Hudiara drain.

In Lahore, six major wastewater drains that are Chota Ravi drain, Suggian drain, Gulshan-e-Ravi drain, Mian Mir drain, Babu Sabu drain and Kharak drain outfall into the river at downstream of Ravi Bridge (Sami, 2001). The waste water from eastern and southern Lahore is carried by Hudiara drain that also drains its effluent into the river Ravi. The impact of this pollution and degradation of water quality greatly affects flora, fauna and also to human being through the food chain as the water of river Ravi has been used for irrigation since many years (Ali, 2003). The municipal and industrial effluents are discharged in the River through 6-major drains at Lahore and its surroundings. In addition, untreated municipal effluents of Lahore city and Shahdara are discharged into the River. The discharge of untreated municipal and industrial effluents has converted the River into a sludge carrier (Ayesha, 2001). The entire municipal waste from Lahore city is collected through a network of 14 different drains and discharged into the River Ravi without

any treatment. The industrial waste is directly discharged into the canal system by 271 industrial units. These industries include textile, chemical, food processing, pulp and paper, poultry, dairy, plastic, paint, pesticides, leather, tanneries and pharmaceuticals (Asad & Ali, 2014). According to Water and Sewerage Authority (WASA) Lahore, the accumulative estimated discharge from these pumping stations is approximately 1650 cusecs (Ejaz et al., 2011). The paper represents that the mixing of effluent in huge quantity without any treatment in Ravi is a serious threat to the environment. During their assessment, the samples were collected from the field and tested in the laboratory using standard methods. The effluent characteristics of Lahore city were also analyzed from the main city outfall sewers and compared with NEQS (National Environmental Quality Standards of Pakistan). Unfortunately, selected parameters are at least four times above the allowable standards and that the environmental condition of Ravi is becoming worse day by day and the river is acting almost a waste water carrier. Increased rate of pollutants in the river may be more dangerous and may create serious threats to groundwater quality and local environment in near future (Ejaz et al; 2011). A large scale of uncontrolled pollution of water in Pakistan is due to the increasing quantity of the pesticides and fertilizers in runoff to meet the demands of increasing population and urban sprawl. Nonfunctional and poorly working factories and industries drain their effluents in the river Ravi in the vicinity of Lahore and its surrounding areas (Briscoe and Qamar, 2008). Many researchers (Akinbile and Yusoff, 2011; Longe and Balogon, 2010; Vasanthi et al., 2008; Abu-Rukah and Al-Kofahi, 2001) have been examined municipal landfills possible impacts on groundwater resources by using microbiological examination and physicochemical analysis of landfill leachate and ground water. They explored that landfill sites are major threats for the groundwater, local environment, and communities as well. Polluting industrial discharges, waste water from municipality are the main causes of irreversible ecosystem degradation.

2.2. Water quality parameters

2.2.1. pH

The effect of pH on the chemical and biological properties of liquids makes its determination very important. It is one of the most important parameters in water chemistry and is defined as -log [H+] and measured as intensity of acidity or alkalinity on a scale ranging from 0-14. If free H+ are more it is expressed acidic (i.e. pH<7), while more OH- ions is expressed as alkaline (i.e. pH >7). In natural water pH is governed by the equilibrium between carbon dioxide/bicarbonate/carbonate ions and ranges between 4.5 and 8.5 although mostly basic. It tends to increase during day largely due to the photosynthetic activity (consumption of carbon-di-oxide) and decreases during night due to respiratory activity. Waste water and polluted natural waters have pH values lower or higher than 7 based on the nature of the pollutant.

2.2.2. Sulphate

Sulphate is the completely oxidized form of sulfur and it is the most stable aqueous form of sulfur under aerobic conditions. Sulfur occurs in several oxidation states ranging from -2 to +6 and its geochemical behavior, including transport and fate, is coupled to the aqueous redox conditions (Hem, 1985; Langmuir, 1997). Sulfate is typically the first or second most abundant anion in natural waters (Hem, 1985). Similar to how aqueous carbonate geo-chemistry is generally considered to exert a primary control over acid-base reactions for natural systems, sulfur geo-chemistry may be considered to represent a primary control over redox reactions for many environmental systems. Sulfate reduction occurs extensively in natural groundwater systems. Sulfate is a redox-defining species in the Terminal Electron Accepting Process (TEAP) sequence, with sulfate reduction occurring after iron reduction and before methanogen conditions. It is the second most reducing condition in natural groundwater system.

2.2.3. Total Hardness

Hardness in water is that characteristic, which prevents the lathering of soap. This is due to presence in water of certain salts of calcium, magnesium and other heavy metals dissolved in it. A sample of hard water, when treated with soap does not produce lather, but on other hand forms a white scum or precipitate. This precipitate is formed, due to the formation of insoluble soaps of calcium and magnesium. Thus, water which does not produce lather with soap solution readily, but forms a white curd, is called hard water. On the other hand, water which lathers easily on shaking with soap solution, is called soft water. Such water consequently does not contain dissolved calcium and magnesium salts in it.

2.2.4. Calcium Hardness

The calcium hardness is a measure of the amount of lime dissolved in the water. Water with a CH of less than 100 ppm (mg/l) is described as soft water and draws lime out of, for example, the concrete of cast pools and tile grouting, leading to disintegration. It also makes the water aggressive. Water with a CH above 300 ppm (mg/l) is described as hard water and causes lime to be precipitated. Lime precipitation causes lime scale to form on the walls and pipes of the pool and in its mechanical equipment. The guideline figure is 100-300 ppm (mg/l). The calcium hardness can be reduced by dilution with fresh mains water and increased with calcium chloride.

2.2.5. Magnesium Hardness

Hard water is not a health hazard but dealing with hard water in the home can be a nuisance. The hardness (calcium and magnesium concentration) of water can be approximated with a home-use water testing kit or can be measured more accurately with a laboratory water test. Water hardness can be managed with packaged water softeners or with a mechanical ion exchange softening unit.

2.2.6. Chlorides

Chloride is a negatively charged ion that is formed when chlorine gains an additional electron. Chloride is generally found in the form of salts, most commonly sodium and potassium salts, which are very soluble in water. Nearly all natural waters contain chloride and the concentrations vary greatly depending on the mineral content of the surrounding rock or soil. Aside from natural sources, chloride enters water from various human sources including: agricultural runoff, road salting, waste water from industry, and produced water from gas and oil wells.

Chlorides are present in all potable water supplies and in sewage, usually as a metallic salt. When sodium is present in drinking water, chloride concentrations in excess of 250 mg/l give a salty taste. If the chloride is present as a calcium or magnesium salt, the taste detection level may be as high as 1000 mg/l chloride. Chloride is essential in the human diet and passes through the digestive system unchanged, thereby becoming one of the major components of raw sewage. The wide use of zeolite spheres in water softeners also contributes a large amount of chloride to sewage and waste waters. High chloride concentrations in water are not known to have toxic effects on humans, although large amounts may act corrosively on metal pipes and be harmful to plant life. The maximum allowable chloride concentration of 250 mg/l in drinking water has been established for reasons of taste rather than as a safeguard against physical hazard. Chemical reactions Mercuric nitrate method Mercuric nitrate reacts selectively with all the chloride present in a sample to produce mercuric chloride and nitrate ions. When all the chloride present in the sample has been completed, excess mercuric ions combine with di-phenyl-carbazide to form a purple-colored complex indicating the end point. Hatch procedures use di-phenyl-carbonize Reagent Powder containing the indicator and a buffer for maximum convenience and reagent stability.

2.2.7. Turbidity

Turbidity is a measure of the cloudiness of water. Cloudiness is caused by suspended solids (mainly soil particles) and plankton (microscopic plants and animals) that are suspended in the water column. Moderately low levels of turbidity may indicate a healthy, well-functioning ecosystem, with moderate amounts of plankton present to fuel the food chain. However, higher levels of turbidity pose several problems for stream systems. Turbidity blocks out the light needed by submerged aquatic vegetation. It also can raise surface water temperatures above normal because suspended particles near the surface facilitate the absorption of heat from sunlight.

2.2.8. Nitrate

Nitrate, or NO^{-3}, generally occurs in trace quantities in surface water. It is the essential nutrient for many photosynthetic autotrophs and has been identified as the growth limit nutrient. It is only found in small amounts in fresh domestic waste water, but in effluent of nitrifying biological treatment plants, nitrate may be found in concentrations up to 30 mg nitrate as nitrogen/L (19^{th} Edition, Standard

Methods, 1995). Nitrate is a less serious environmental problem, it can be found in relatively high concentrations where it is relatively nontoxic to aquatic organisms. When nitrate concentrations become excessive, however, and other essential nutrient factors are present, eutrophication and associated algal blooms can be become a problem (Fundamentals of Aquatic Toxicology, 1985).

2.2.9. Sodium

Sodium is one of the most abundant elements and is a common constituent of natural waters. The sodium concentration of water is of concern primarily when considering their solubility for agricultural uses or boiler feed water. The concentration ranges from very low in the surface waters and relatively high in deep ground waters and highest in the marine waters. It is calculated by flame photometric method.

2.2.10. Potassium

Potassium occurs in rocks in a form that is not easily solubilized; therefore, the potassium content of natural waters is usually low. Most natural waters contain less than 20 mg/l of potassium, but waters containing several hundred milligrams per liters are occasionally found. Potassium ranks seventh among the elements in order of abundance, behaves similar to sodium and remains low. Though found in small quantities (<20mg/L) it plays a vital role in the metabolism. Potassium is essential to animal nutrition, but a concentration of 1000 to 2000 mg/l in stock water is regarded as the extreme limit permissible. 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.

2.2.11. Total Dissolved Solids (TDS)

The Total Dissolved solids are solids that are in dissolved state in solution. Water with high dissolved solids generally are of inferior palatability and may induce an unfavourable physiological reaction in the transient consumer.

2.2.12. Coliforms

These are a group of bacteria that are found widely in the environment as well as in the gut of warm blooded animals. They should not be in the water supply and are removed by an effective disinfection process. The regulatory standard is 0 per 100 ml of water.

Most coliforms are not harmful in themselves, but their presence in a water sample can indicate that there is a problem with the disinfection process or the structural integrity of the distribution system. All failing samples should be investigated, and the outcome reported to DWQR (Drinking Water Quality Regulation). Failure of a consumer tap sample may be due to the condition of the tap itself, rather than the quality of the water supply.

E. coli (Escherichia coli) is a bacterium, and a member of the coliform group. Sometimes known as Fecal coli forms, they are only found in the gut of warm-blooded animals, so their presence in drinking water can indicate contamination of the water supply by faecal matter. They are removed by the disinfection process at water treatment works. The regulatory standard is 0 per 100ml of water.

2.2.13. Manganese

Manganese occurs naturally in some water sources, where it is dissolved from the surrounding rocks and enters the water supply. Appropriate treatment can remove it, but where this is not present manganese can cause black discoloration of supplies. Manganese deposits can coat water mains, causing problems long after the treatment process has been improved. Due to geological factors, manganese tends to be more of a problem in parts of Western Scotland, especially at certain times of year.

2.2.14. Arsenic

This element is very widely distributed throughout the earth's crust, according to the WHO Guidelines, which state that "it is introduced into water through the dissolution of minerals and ores, from industrial effluents, and from atmospheric deposition: concentrations in ground water in some areas are sometimes elevated as a result of erosion from natural sources. The average daily intake of inorganic arsenic in water is estimated to be similar to that from food; intake from air is negligible." Arsenic is used in the glass and semiconductor industries and as a fungicide in timber processing. A major US emission source is coal-fired power plant.

Very toxic to humans, some arsenical compounds are carcinogens, hence much of the concern regarding them, but there are a variety of other effects on health. The WHO states that inorganic arsenic is a documented human carcinogen, and that a relatively high incidence of skin and possibly other cancers that increase with dose and age has been observed in populations ingesting water containing high concentrations of arsenic.

3. METHODOLOGY & MATERIALS

3.1. Location

The following locations are selected for water sampling nearby different drains. As shown in Figure.1 and Table.1.

3.2. Data Collection and analysis

The primary data were collected from different location nearby different drains surrounding Lahore city. As listed in Table.1. In this study, water samples were collected from different locations, then water samples were sent to Pakistan Council of scientific and Industrial Research (PCSIR) Laboratory, Lahore for analysis of water quality parameters. After then these results were analysed and prepared graph.



Fig.1 Location map of water sampling points

Table.1 List of locations of water quality sampling points

Sr. #	Water Samples Detail	Sample I.D
1	Marghzar Colony Near Motorway from Pump, Depth 300ft, Lahore	GWS-1
2	Sabzazar Disposal Station at the end of Kharak Nallah, from Pump at depth 150ft. Lahore	GWS-2
3	Sabzazar Disposal Station at the end of Kharak Nallah, from Pump at depth 400ft. Lahore	GWS-3
4	Sabzazar Disposal Station at the end of Kharak Nallah, from Pump at depth 100ft	GWS-4
5	Shahdara pumping station near Shahdara, Shahdara, depth 60ft. Lahore	GWS-5
6	Ravi Clifton pumping station near Shahdara, depth 150ft. Lahore	GWS-6
7	Mehmood Booti from pump at depth 100ft. Lahore	GWS-7
8	Mehmood Booti from pump at depth 350ft. Lahore	GWS-8
9	Mehmood Booti from pump at depth 200ft. Lahore	GWS-9
10	Along river Ravi River	GWS-10
11	Along river Ravi River	GWS-11

4. RESULTS AND DISCUSSION

The ground water quality parameters (physicochemical and microbiological) results were compared with National Environmental Quality Standards (NEQS) for drinking purpose. The groundwater samples were collected from five locations (11 samples) including Marghzar colony, Shahdara, Sabzazar, Mehmood Booti site and along Ravi River. The groundwater samples were taken from water pumps/hand pump at different depths of 50, 60, 100,150,300, 350,400ft. These

samples were analyzed by the Pakistan Council of Scientific and Industrial Research (PCSIR) laboratories. Results are discussed below.

4.1. pH

The results of high and low flow seasons of pH of all samples are acceptable and lies within permissible limits. As shown in **Fig.2**.

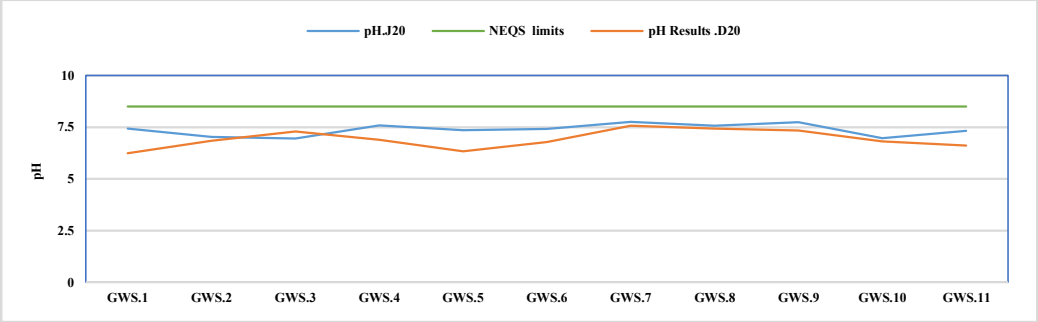


Fig.2 Results showing **pH** values for high and low flow seasons.

4.2. Total dissolved solids

The groundwater contamination in high flow season is more as compared to low flow season.

In case of High flow season: The water quality analysis results shows that quality of six samples (GWS-2, 3, 7, 8, 9, 10) exceed limits. Wherein, four samples GWS-1, 4,5,11 within limits. It applies that TDS at shallow depth are less as compared to deep.

In **case of low flow season:** GWS-1,2,3,5,6,7 ,11 lies within limits wherein, rest of the samples (GWS-4,8,9 &10) exceeds limits.

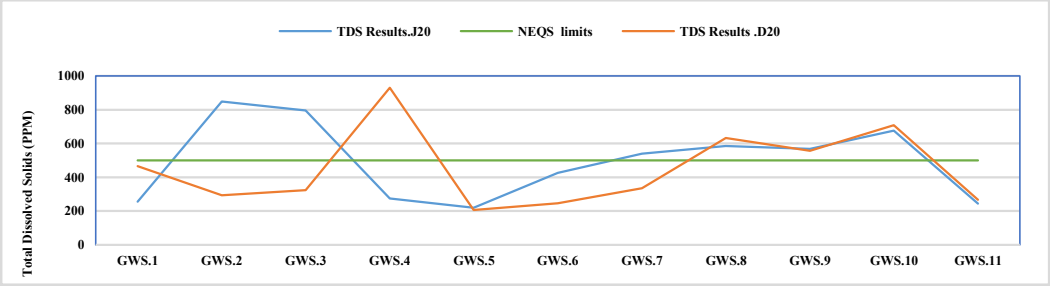


Fig.3 Results showing **TDS** values for high and low flow seasons

4.3. Total Hardness

Concentration of total hardness is more in high flow season as compared to low flow season.

In case of high flow season: The water quality analysis results shows that quality of(GWS-2,3,7,8,9,10) exceed limits wherein,GWS-1,4,5,6,11 within limits

In case of low flow season: GWS-4,10 exceeds limits wherein, rest of the samples are found within limits.

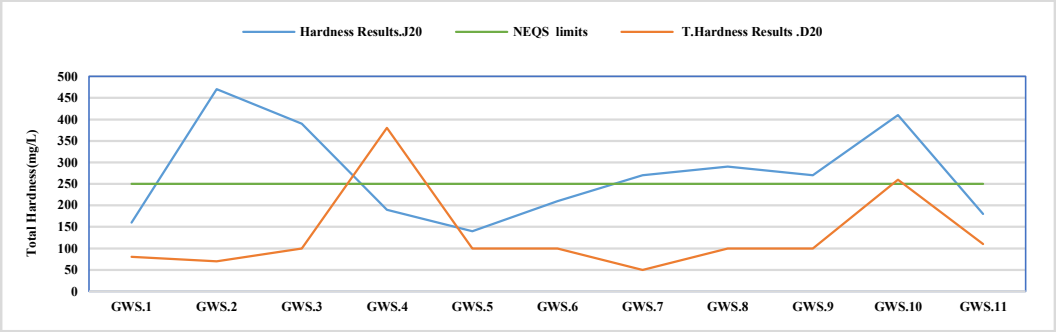


Fig.4 Results showing **Total Hardness** values for high and low flow seasons

4.4. Magnesium

The groundwater quality analysis results reveals that all the samples of Low as well as high flow seasons exceeds permissible limits.

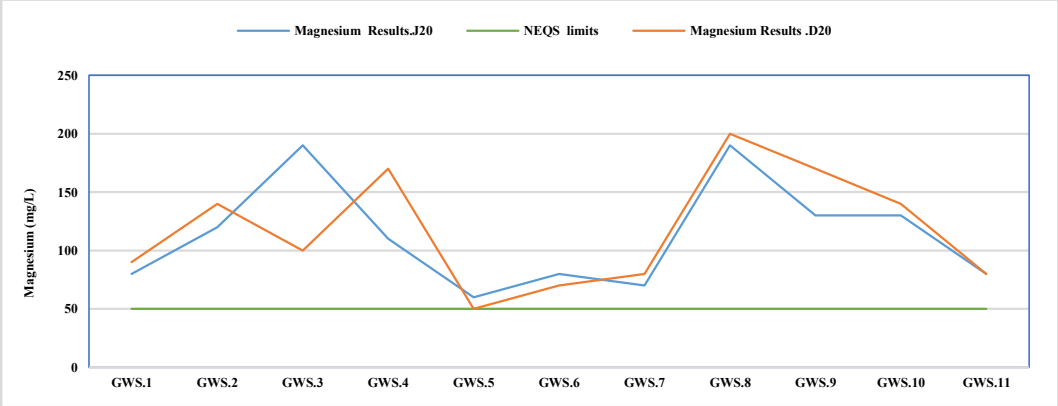


Fig.5 Results showing **magnesium** values for high and low flow seasons.

4.5. Calcium

In case of high flow season: The water quality analysis results shows that quality of groundwater nearby Sabzazar Disposal station (GWS-3) at shallow depth of 150 ft**,** Marghzar colony (GWS-1) and Mehmood Booti Site (GWS4) @100ft was within permissible limits wherein, rest of the samples exceeds limits.

In case of low flow season: Marghzar colony (GWS-1), Mehmood Booti (150f), Sabzazar (100ft) and Shahdara site(60ft) were found within limits, wherein, rest of the samples exceeds limits. It applies that Calcium content at shallow depth is less as compare deep.

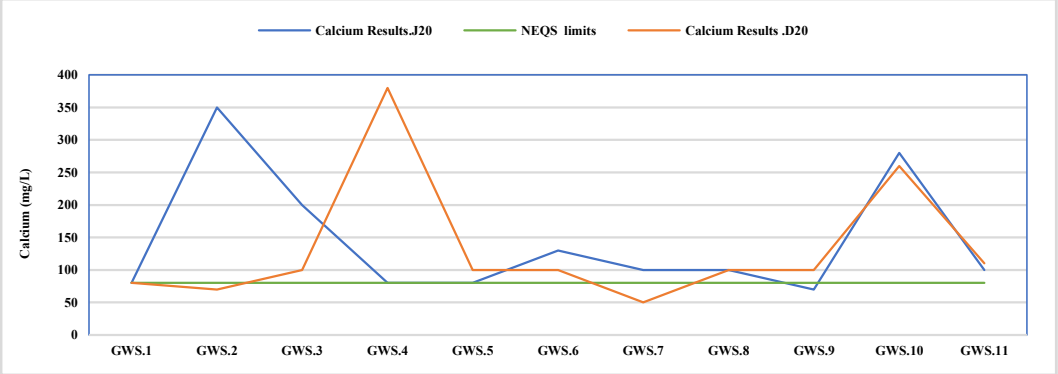


Fig.6 Results showing **calcium** values for high and low flow seasons.

4.6. Sodium

Deficiency of sodium in the body might appear as low blood pressure, fatigue, depression, dehydration etc. Overdose can cause hypertension, stroke, headaches, kidney damages, stomach problems and nausea. There were no samples having balance sodium content. In low flow season, six samples are under permissible limits and five over limits. In High flow season, four samples are under permissible limits and seven over limits.

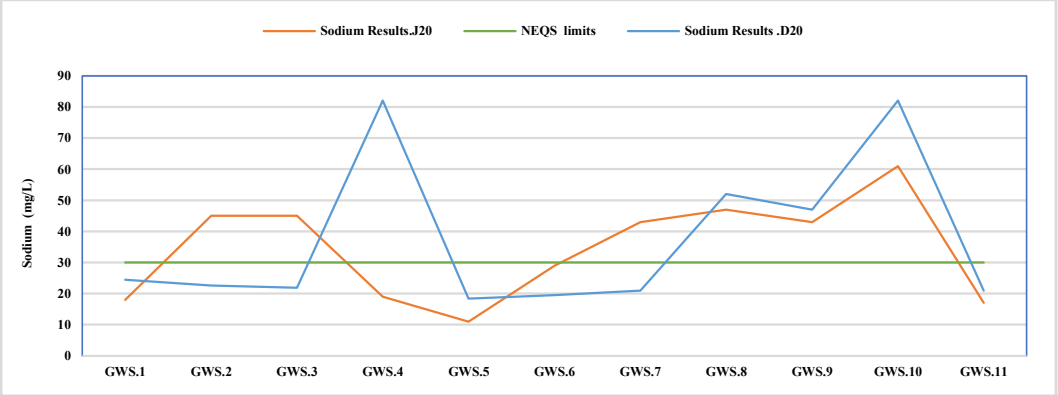


Fig.7 Results showing **sodium** values for high and low flow seasons.

4.7. Chloride

The results shows that all the samples of low as well as high flow seasons are within permissible limits.

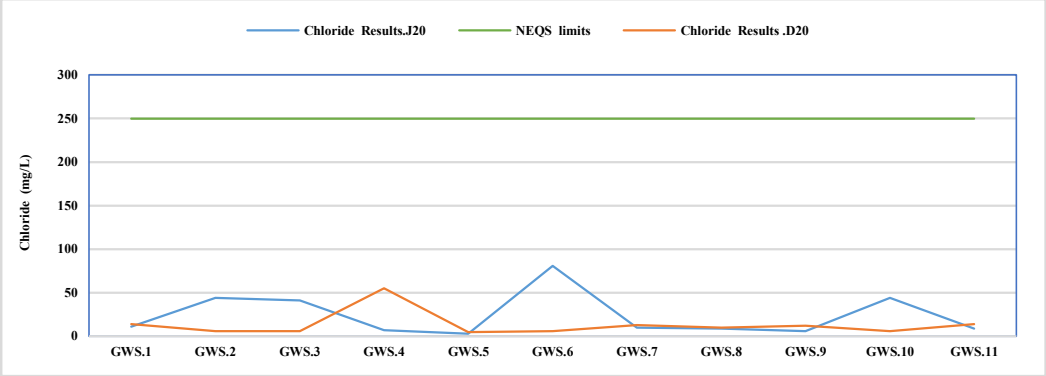


Fig.8 Results showing **chloride** values for high and low flow seasons.

4.8. Sulphate

Results show that all the samples of low as well as high flow seasons are within permissible limits.

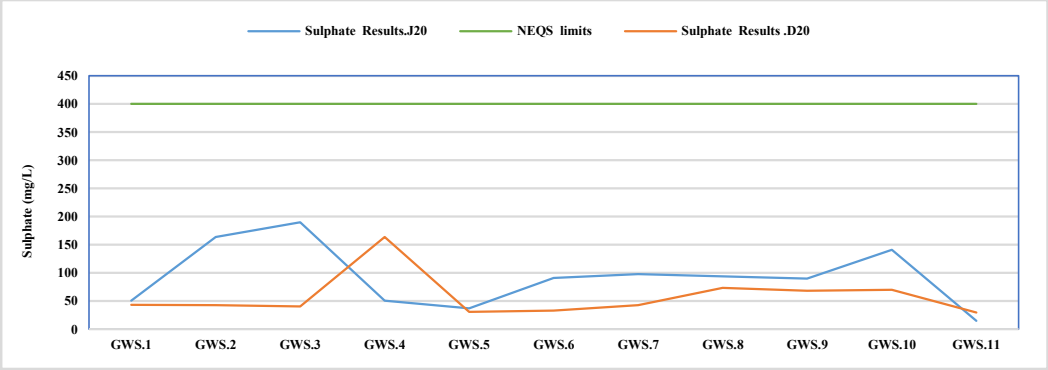


Fig.9 Results showing **Sulphate** values for high and low flow seasons.

4.9. Arsenic

Results show that all the samples of low as well as high flow seasons exceeds permissible limits except one sample of Mehmood Booti site (high flow season).

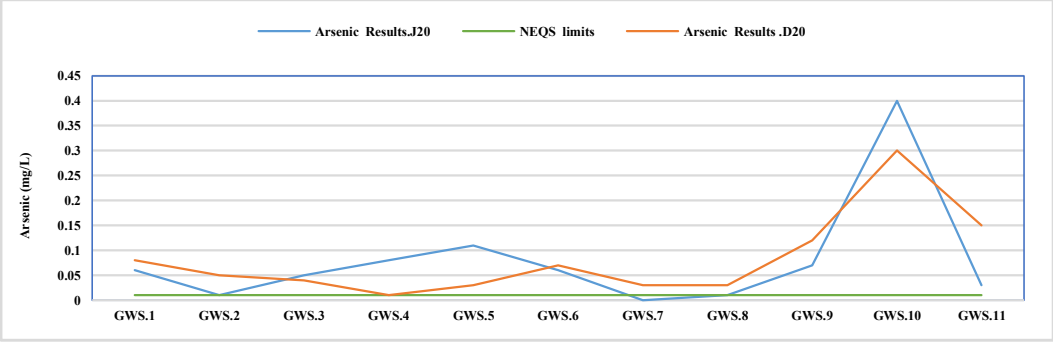


Fig.10 Results showing **Arsenic** values for high and low flow seasons.

4.10. Total Plates count

In case of high flow season: only four sites lie within permissible limits wherein, rest of the sites are not fit for drinking purpose.

In case of low flow season:GWS-3, 4, 5,7,8,9 within limits wherein, rest of the sites are not fit for drinking purpose.

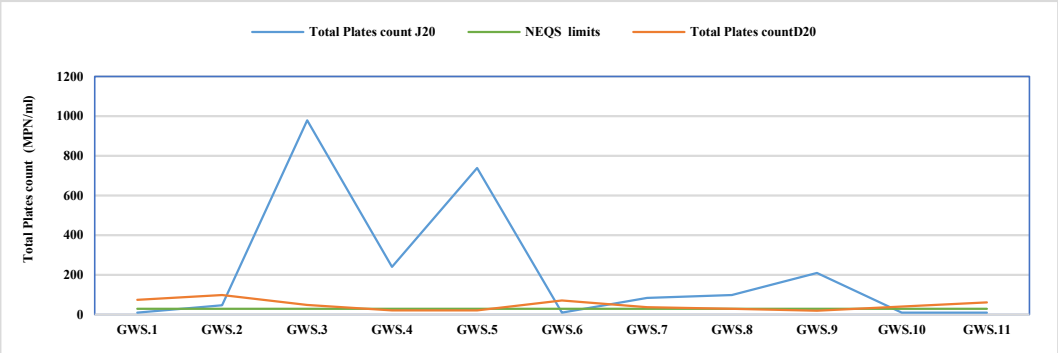


Fig.11 Results showing **total plates count** values for high and low flow seasons.

4.11. Faecal coliforms

In case of high flow season. All the samples exceed permissible NEQS limits.

In case of low flow season. GWS-2,3,4,5 exceeds limits wherein, rest of the sites lies within permissible limits.

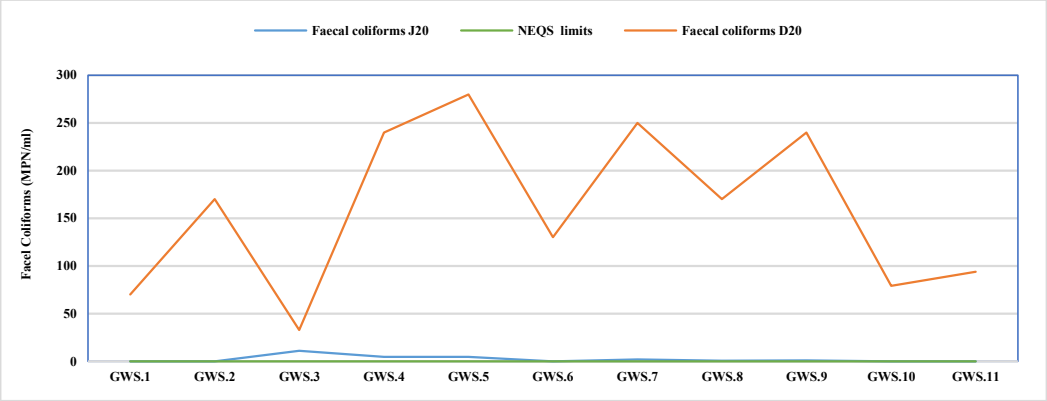


Fig.12 Results showing **faecal coliforms** values for high and low flow seasons.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

- **Marghzar Colony (GWS-1):** Magnesium, Faecal coliforms and total plates counts exceed permissible limits (both seasons). Also contain higher concentration of “Arsenic” In **low as well as high flow season thus**, it may cause skin disease cancer especially in the old age people. Due to higher concentrations, it is unfit for drinking purpose.

- **Sabzazar stations areas** (GWS2@150ft, GWS-3@400ft, GWS-4@100ft). It can be concluded from results that groundwater quality at Sabzazar site is not suitable for drinking purpose. Due to higher concentrations of Arsenic, faecal coliform, total plates count total hardness, calcium and magnesium exceed limits in both seasons. Further, at shallow depth (100ft), nitrate, nitrite and cyanide exceed limits. Due to higher concentrations, it is unfit for drinking purpose.
- **Shahdara site (**GWS-5@ 60ft, GWS-6@150ft**):** Results shows that concentration of calcium, magnesium, arsenic, faecal coliforms, total plates counts exceed in both samples in both season. Nitrite also exceeds @ higher depth in both seasons. Due to higher concentrations, it is not fit for drinking purpose.
- **Mehmood Booti** (GWS-7@100ft, GWS-8@350ft, GWS-9@200ft)

  TDS @ shallow depth of 100ft found within limits, where at 200ft and 350ft exceeds limits**.** Concentration of total hardness**,** in case of low flow season lies within permissible limits. While**,** in high flow season exceeds permissible limits. Magnesium exceeds in both seasons. **Calcium,** in low flow season, at shallow depth of 100ft lies within limits but at higher depth of 200 & 350 ft exceeds limits. **While,** in high flow season, all samples results exceed limits. **Sodium:** at shallow depth @100ft within limits wherein, 200ft and 350ft exceeds limits in both seasons. **Faecal** Coliforms, Total plates counts and arsenic exceed all samples in both seasons. Therefore, it can be concluded the ground water quality of Mehmood Booti site is not fit for drinking purpose.
- **Samples collected nearby Ravi River (GWS-10, GWS-11)**

  GWS-10: TDS, Total hardness, calcium, magnesium, total plates counts, faecal coliforms, and arsenic water quality parameters exceeds limits in both seasons.

  GWS-11: Calcium, magnesium, total plates counts, faecal coliforms, and Arsenic exceeds limits in both seasons. Due to higher concentration, ground water quality is not fit for drinking purpose.
- Three water quality parameters includes Chloride, Sulphate, pH found with permissible limits (In all samples).
- Four water quality parameters includes Arsenic, Magnesium, Total plates counts and faecal coliforms exceeds permissible limits (In all samples).
- Calcium also exceeds in both seasons except only one sample collected from Mehmood Booti @ shallow depth.
- Total hardness in high flow season is more than low flow season.

- Quantity of TDS is more in case of high flow season as compared to low flow season.

6. Recommendations

- As temporary hardness (magnesium and calcium) more than permissible limits. Therefore, it is recommended to use boiled water for drinking purpose.
- As all the samples contain microbiological contaminations. Therefore, it is recommended, groundwater sources should be kept protected so that animal /human waste don't mix in the groundwater.
- Industrial waste should be treated before discharging into drains/ River. So that ground water is not contaminated by nearby drains and areas surrounding River.
- Recharge wells should be installed at different locations in urban areas for recharging groundwater through rain water.
- Lined drains so that ground water through seepage from drains is not contaminated.

7. REFERENCE

Abdul, R., Muhammad, J., Muhammad, U., & Sajid, A. (2009). Assessment of heavy metals in sediments of the river Ravi, Pakistan. *International Journal of agriculture and Biology*, *11*(2), 197-200.

Abu-Rukah, Y., & Al-Kofahi, O. (2001). The assessment of the effect of landfill leachate on ground-water quality—a case study. El-Akader landfill site—north Jordan. *Journal of Arid Environments*, *49*(3), 615-630.

Akinbile, C. O., & Yusoff, M. S. (2011). Environmental impact of leachate pollution on groundwater supplies in Akure, Nigeria. *International Journal of Environmental Science and Development*, *2*(1), 81

Asad Qureshi & Ali Hasnain Syed situation analysis of the water resources of Lahore: establishing a case for water stewardship, WWF-Pakistan 2014.

Ayesha A (2001). Water quality assessment of River Ravi around City Lahore. Pakistan Engineering Congress, 71st Annual Session Proceedings. 636-648.

Briscoe, J., Qamar, U., Contijoch, M., Amir, P., & Blackmore, D. (2006). *Pakistan's water economy: running dry*. Karachi: Oxford University Press.

Ejaz, N. A. E. E. M., Hashmi, H. N., & Ghumman, A. R. (2011). Water quality assessment of effluent receiving streams in Pakistan: A case study of Ravi River. *Mehran University Research Journal of Engineering & Technology*, *30*(3), 383-396.

Haider, H., & Ali, W. (2010). Development of dissolved oxygen model for a highly variable flow river: A case study of Ravi River in Pakistan. *Environmental modeling & assessment*, *15*(6), 583-599.

Haider, H., & Ali, W. (2013). Evaluation of water quality management alternatives to control dissolved oxygen and un-ionized ammonia for Ravi River in Pakistan. *Environmental Modeling & Assessmen 18*(4), 451-469.

Muhibbah-Din, O. I., Aduwo, A. O., & Adedeji, A. A. (2011). Study of physiochemical parameter of effluent impacted stream in Obafemi Awolowo University, Ile-Ife, Nigeria. *Unpublished undergraduate report submitted to the Department of Zoology, Obafemi Awolowo University, and Ile-Ife, Nigeria*.

Sami, F., & PEP (2001). Water quality monitoring of Hudiara drain', an independent consultancy for data analysis and water quality management plan.*PEP Department, Editor*.

Vasanthi, P., Kaliappan, S., & Srinivasaraghavan, R.(2008).Impact of poor solid waste management on ground water. *Environmental monitoring and assessment*, *143*(1-3), 227-238.