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Deterioration of Ground Water Quality through Seawater Intrusion in Coastal Area of District Badin Sindh Pakistan.

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Abstract

Various zones of the world usages for agriculture are groundwater and the main source of fresh water resources in the coastal area are seriously affected by seawater intrusion. The population density is increasing at disturbing rates, Fresh groundwater resources are depleted, and raising the importance of groundwater monitoring. Pakistan is especially helpless against climate change since it has a warm climate; it is land region is generally bone-dry and semi-dry areas. The fundamental reason for choosing District Badin was assessing the quality of drinking water for human utilization. Large coastal areas of Badin are exceptionally influenced via seawater intrusion. Investigation areas are progressively becoming ecological disaster zones. The severe intrusion of seawater caused the seriousness of the above issue, the groundwater quality examination was intended to survey the after all impacts of seawater interruption on groundwater. The study was conducted in the different locations of the coastal area of District Badin facing seawater intrusion problem. From different sources, sixty samples were collected from electric motors and hand pumps, at twelve selected sites. The analyzed data were evaluated and compared with WHO standards parameters of groundwater contemplate were: EC, pH, Potassium, Na^+, Ca^2, Mg^2, Cl_2-, Turbidity, (TDS), Smell, Shading, F -, As3, Microbiological Tests analyzed by kit method. The microbiological results were within the safe limits then Results were compared with WHO standards, results confirm that selected areas of Badin have poor water quality and it is unfit for drinking, all the parameters were above the safe limits and quality of water is unfit for drinking.

Keywords: Groundwater; Seawater; Intrusion; Water; Areas

Introduction

Freshwater is life, without it, the earth would be an unfertile desert. The supply of water is limited; however, assert is developing quickly due to population growth and water utilization per capita increments. Separate activities to meet upcoming alternatives. Around 34,000 cubic kilometers of freshwater are accessible universally for human use each year. In the event that equitably spread this would convey every individual with around 8,000 cubic meters of water every year of the population [1]. This amount would be adequate to meet human necessities if freshwater were equally disseminated.

In any case, existing freshwater supplies are not scattered reliably around the earth, in the course of the circumstances, increase in water from year to year compelled to utilize groundwater. Contamination of waterways and lakes lessens available freshwater, surface, and groundwater supplies. Every year about 450 cubic kilometers of wastewater is released into waterways, streams, and lakes below the soil surface. The movement of groundwater weakens and transport this filthy water before it can be utilized once more, another 6,000 cubic kilometers of clean water is required which is a sum equivalent to around 66% of the world's aggregate yearly useable esteemed water overflow. The volume of water that individuals utilize depends not just on fundamental needs and how much water is accessible yet in addition to levels of urbanization and monetary improvements.

The world's incredible ocean is the core of the hydrological cycle - nature's sun-powered driven water pump. Around 430,000 cubic kilometers of the water dissipates from the seas consistently. Of this sum, around 110,000 cubic kilometers fall as freshwater precipitation over land, recharging surface and ground waters and inevitably finishing the cycle by coming back to the ocean [2]. The sea is additionally motorized that drives the world's atmosphere, putting away gigantic amounts of sun-oriented vitality all the while. The sea assimilates and stores carbon dioxide from the air. Since this undetectable gas is one of the primary operators of environmental change, the sea is a vital sink that alters human effects on the worldwide atmosphere. Sea streams, the blue planet's super interstates, exchange huge amounts of water and supplements starting with one place then onto the next. The Inlet Stream, for example, drives more water from the Bay of Mexico and the Caribbean over the Atlantic into northern Europe, that is conveyed by every one of the waterways on earth. Worried about ocean level ascent (SLR) impact on saltwater interruption (SWI) had a grown-up for the most current period and various examinations have tended to the degrees, taxes and periods related with the SWI prompted by SLR generally for similar problems.

In layered aquifers, the vertical flow through layers makes the discontinuous system with a homogeneous. The pollution of new groundwater by saltwater interruption (SWI) turns into an overall disturbing issue, which debilitates all nations relying upon groundwater deliberation from seaside zones.

Different methods for treatment and control have continued recommended for predicting SWI. The development of subsurface physical interruptions was standout amongst the handiest usage strategies to forestall SWI. In this world, groundwater is the key wellspring of crisp water. With the worlds, Populace developing at disturbing rates, the crisp oceanic source is, as a rule, much of the time depleted, expanding the essentialness of groundwater observing. Pakistan is particularly defenseless against environmental change since it has overall a warm atmosphere, its property locale is for the most part dry and semi-bone-dry territories. According to the Intergovernmental Board on Environmental Change [3]. The making of the littlest and set up countries depend on to endure more due to environmental change, when stood out from the setup. There are a couple of components that can impact the amount and the nature of groundwater resources, however, in shoreline aquifers, seawater interruption is consistently the most significant issue with respect to freshwater supply.

Pakistan's monstrous water framework structure includes three essential storing supplies, 19 surges or flow, 43 central channels through an advance measurement of 57,000 km, and 89,000 conduits with a consecutive distance of in excess of 1.65 million km. The sorting immerses in excess of 40 million segments of land-living overseeing. Pakistan the most important overflowed and rain-fed arrive extent on the planet. This vital water framework is, in any case, taking a mind-boggling toll. Thatta, an overwhelmingly agrarian region in Sindh Territory, and masterminded where the Indus stream streams into the Middle Eastern Ocean, has been rendered even more horrendous off. The entire lands of districts of the region are in excess of 4.29 million segments of land, yet its third has now been assaulted by the seawater. "Around 1.2 million segments of place that is known for a productive place where there are Thatta and adjoining ranges is by and by clearly or roundabout impacted by the sea water" [4].

The Indus Delta is located in the southeastern Pakistani drift, with a region of about 600,000 hectares (ha) Ranger service Segment Groundbreaking strategy, 1992), stretching out from the Korangi River in the north to the Sir Rivulet in the South along the four southern regions of the Sindh region of Pakistan i.e. Karachi, Thatta, Sujawal and Badin [5].

In the past, the freshwater flow in the delta was about 150 million-acre feet (MAF). In recent years, although 10 FUZ per year have agreed on the agreement between the provinces, the flow under Kotri was significantly lower from year to year. The Indus used to bring the silt that was a rice mill. These cactus-rich deposits were the main reason for the fertility of the waterfront. The construction of dams and paths, however, has prevented the mud from reaching the river downstream. In addition, the Indus River was designed to prevent seawater disturbances on land along the banks of the delta region. Today, the delta coastal ecosystem has been underlined by the intrusion of seawater and an increase in salinity. Many areas along the coast have been flooded and the livelihoods of coastal and coastal fishing communities are under pressure. Reducing freshwater inputs in the Indus River and using natural resources also affected the mangrove ecosystem Delta Indus coast. The coastal areas of the Badin region are heavily affected by the seabed, and the vast land area ended up impoverished. Due to this problem, this area has been relocated to the Environmental Disaster Zone by examining the gravity of the above case where the study is planned, assessing all impacts of the seabed on the type of groundwater in the area and its impact on the population.

The fundamental reason for choosing District Badin was to conduct research on the drinking water quality status for human utilization. The coastal zones of District Badin were exceptionally influenced via seawater intrusion and due to this problem, considering the seriousness of above problems, the purpose of the examination is to study the impact of seawater intrusion on the nature of groundwater.

Objectives of the Study

a) To determine physio-chemical properties of ground water in the selected coastal areas of District Badin as affected by seawater intrusion.

b) To suggest the suitable strategy to mitigate the sea water intrusion problem in the area.

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Material and Methods

Location of the research area

The District Badin is located between the northern 24º-5` to 25º-25` and 68 21 'to 69 20' east longitude. The area is surrounded by the eastern parts of the Mirpurkhas and Tharparkar areas to the north of the Hyderabad area, south of the Arabian Sea and Rann of Kutch, which also borders the creation border with India, and westward, borders Thatta and Hyderabad regions. The total area of the District is 6.726 square miles and area is divided into five Taluka, of Badin, Matli, Tando Bago, Golarchi and Talhar and with the presentation of the Devolution System, the talukas have been under-insulated in the Union Councils numbering 49, Tapas 109 and Dehs 511.

To study drinking water quality status of selected areas of District Badin for human utilization, the water samples were collected from Badin. Town Bhugra Memon, Village Ahmed Nohrio, Village Seerani, Village Ahmed Rajo, Village Baksho Dero, Village Meeanh wasayo Mallah, Village Mehar Dhandhal, Zero-point Golarchi, Village Wakeel Mori, Village Hussein Mallah, Morio Mendhero, UC Ahmed Rajo. Groundwater quality samples were collected from each proposed area from the source hand pumps, and electric motors to study the water quality of drinking water. The pump was a fundamental source of water for sampling purpose

Collection of water samples

The water samples were collected for determination of physicochemical parameters in each selected area of the District Badin, Sindh, Pakistan. For assessment of safe drinking water 12 locations of Badin District shows in (Figure 1) were chosen for water sampling, 05 samples were collected from every location. Surface water wasn't observed in the study area. Along these outlines, the water samples were collected from hand pumps and Tube well. Preference was given to those water pumps which were frequently utilized for drinking purpose. The samples were collected, sorted systemically, indicating the date, code at top of the samples bottle.

Figure 1: Water sampling locations of Badin District.

A survey sheet of the single page was filled by a local community of that area, before collection of samples from the selected area. The survey contains code name, time and date of sample collection, source of water and source of energy and so on. Moreover, data about drinking water quality and comfort impacts were collected through a proposed survey as given in reference section A. For assessment of drinking water quality, Samples of water were collected in 500ml polyethylene bottles. Before collecting samples, the bottles were washed with precision and flushed with refined water to expel debases. Water samples were collected from electric pump flowing 3-5 minutes cleansing. Later polyethylene bottles and capes were washed with samples water and after that same water collected in the bottles.

Physico-chemical parameters of groundwater quality

These parameters were determined in the laboratory of DRIP, using standard methods. Details of each method are given in the subsequent paragraph.

Physical water quality parameters: The physical parameters of the water samples include pH, Electrical Conductivity, Color, Odor and Turbidity.

Chemical water quality parameters: The chemical parameters include Alkalinity, Bicarbonates, Carbonates, Calcium, Magnesium, Sodium, potassium, Hardness, chloride, Sulfate.

Microbiological water quality parameters: The microbiological parameter of water was analyzed by the kit method.

Techniques used to analyze the groundwater quality

Water quality parameters and kit methods used for investigation are given below. Every sample was investigated in the research center at Drainage and Reclamation Institute of Pakistan (DRIP) at Tando Jam. All parameters were associated with the World Health Organization (WHO) guidelines.

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In each Sample's physicochemical investigation color and odor were observed by physical technique and in a chemical investigation, titration technique was used for investigating the

anions (CO3, HCO3, and Cl), cations (Ca and Mg), Alkalinity and EDTA titration for Hardness exposed in Table 1.

Table 1: Water quality parameters.

Parameters	Methods
Odor	sensory Evolution
Color	sensory Evolution
pH	Digital pH meter
(EC)	Digital EC meter
(TDS)	TDS meter
Bicarbonates	Titrimetric Titration Method
Calcium	EDTA Titration Method
Magnesium	EDTA Titration method
Sodium	Flame Photometer
Potassium	Flame Photometer
Hardness	EDTA Titration Method
Chloride	Argentometric Titration method
Sulfate	Colori Meter DR/890
Nitrate	Colori Meter DR/890
Fluoride	Colori Meter DR/890
Arsenic	Kit method
Microbiological Test	Kit method

Results

The results regarding the color and odor of collected samples were given in Table 2. From the table, it can be noted that all samples were safe in-terms of color and odor for drinking purpose.

Table 2: Color and odor of water sample.

Sr. No.	Sample Code	Color	Odor
1	BDN 1	Clear	Nil
2	BDN 2	Clear	Nil
3	BDN 3	Clear	Nil
4	BDN 4	Clear	Nil
5	BDN 5	Clear	Nil
6	BDN 6	Clear	Nil
7	BDN 7	Clear	Nil
8	BDN 8	Clear	Nil
9	BDN 9	Clear	Nil
10	BDN 10	Clear	Nil
11	BDN 11	Clear	Nil
12	BDN 12	Clear	Nil

PH of ground water

The results regarding the pH of the study area are shown in Figure 2. It can be noted from figure that minimum pH value (7.5) was observed in Seerani village that was 15% lower as compared to the highest value, and the maximum pH (8.4) was observed in Wakeel mori and Mehar Dhandhal villages which were 29% higher than the minimum value. While the pH of groundwater in remaining villages were within the standards of WHO. Therefore, it is safe in terms of ph.

The straight lines show upper and lower boundary limits of pH, it can be seen from the graph that none of the bars crossed the permissible limits. It means the pH value of all collected samples were in safe range according to the WHO standards.

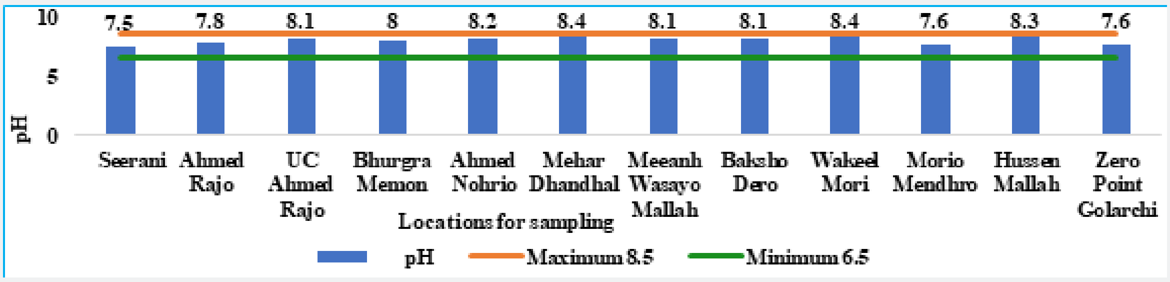

Figure 2: Ground water analysis for pH showing different villages of Badin.

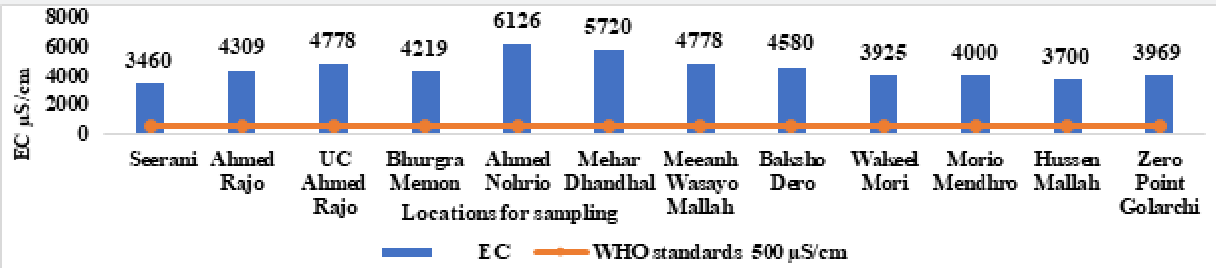

Figure 3: Comparison of EC of ground water samples of different villages of study area.

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Electrical Conductivity (EC) of groundwater

The results regarding the EC of groundwater samples of the study area are shown in Figure 3. It can be notated from the figure that minimum EC value (3460μS/cm) was observed in Seerani village that was 592% lower as compared to highest value and the maximum value (6126 μS/cm) was in Ahmed Nohiro village which was 1125% higher than the lowest value. The EC of groundwater in remaining villages were above the acceptable limits as per WHO.

It can be seen from the graph the all bars of collected samples from different village's crosses the permissible limits it means that the water samples were highly saline which shows complete intrusion of seawater into these village.

Total dissolved solids (TDS) of ground water

The results regarding the total dissolved solids of the study area are shown in Figure 4. It can be notated from the figure that minimum total dissolved solids value (2589 mg/l) was observed in Ahmad Rajo village that was 159% lower than the highest value and the maximum value was (6059mg/l) observed in Ahmed Nohiro village that was 506% higher than the lowest value. Whereas the total dissolved solids of groundwater in remaining villages were above to acceptable limits as per WHO.

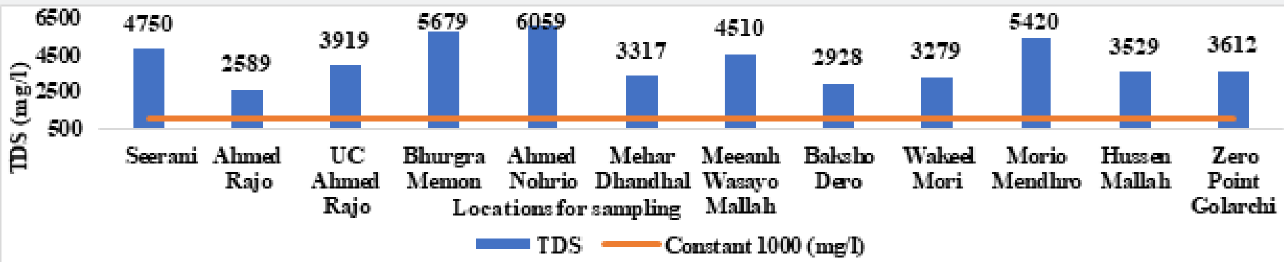

Figure 4: Ground water analysis for Total Dissolved Solids (TDS) for different villages of Badin.

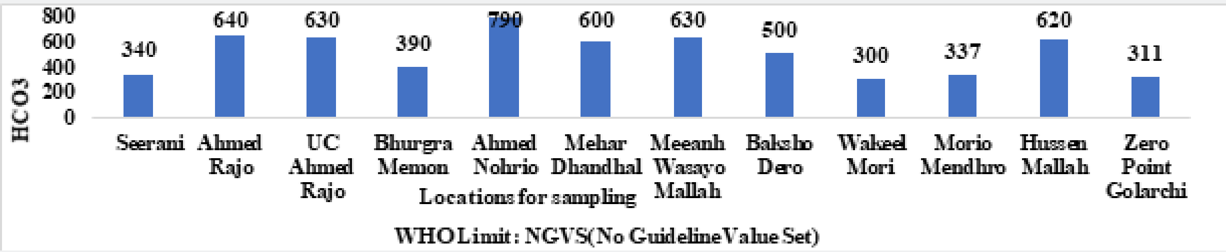

Figure 5: Ground water analysis for Bicarbonates (HCO3) of ground water for different villages of Badin.

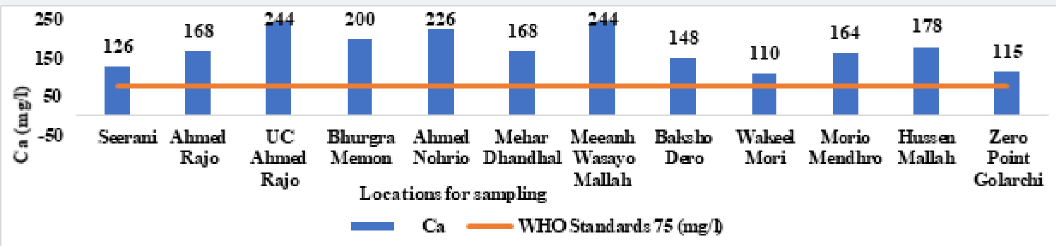

Figure 6: Ground water analysis for (Ca) calcium showing different villages of Badin.

Bicarbonates of ground water

The results regarding Bicarbonates of the study area are shown in Figure 5. It can be notated from the figure that minimum bicarbonates were observed (311mg/l) in Zero Point Golarchi and the maximum was observed (790mg/l) in In Ahmed Nohiro village.

Calcium of ground water

The results regarding Calcium of the study area are shown in Figure 6. It can be notated from the figure that minimum Calcium was observed (110mg/l) in Wakeel Mori village that was 47% lower than the highest value and the maximum was observed (244mg/l) in UC Ahmed Rajo and Meeanh Wasayo Mallah villages that were 225% higher than the lowest value. Whereas the calcium of groundwater in remaining villages was above to acceptable limits as per WHO.

It can be seen from the graph the all bars of collected samples from different villages crossed the permissible limits it means that the water samples were highly saline which shows the complete intrusion of seawater into these villages

Magnesium of ground water

The results regarding Magnesium of the study area are shown in Figure 7. It can be notated from the figure that minimum

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Magnesium was observed (130.37mg/l) in Seerani village that was -13% lower than the highest value and the maximum value was observed (203.75mg/l) in Ahmed Nohiro village that was 36% higher than the lowest value. Whereas the Magnesium of groundwater in remaining villages were above to acceptable limits as per WHO

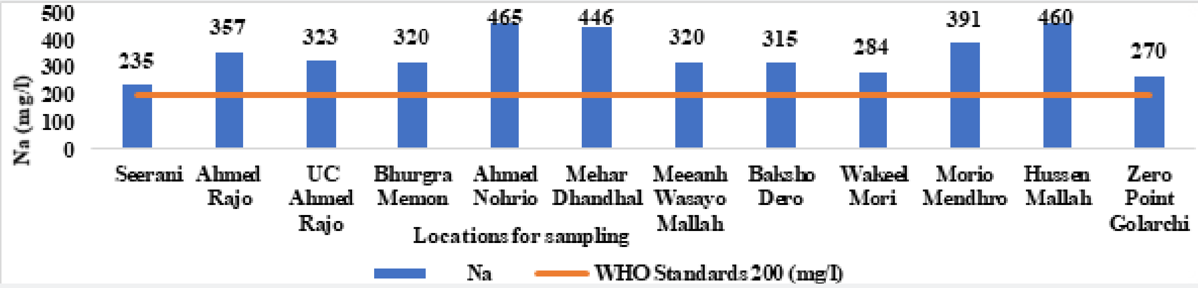

Figure 7: Ground water analysis for (Mg) Magnesium for different villages of Badin.

It can be seen from the graph the all bars of collected samples from different villages crossed the permissible limits it means that the water samples were highly saline which shows the complete intrusion of seawater into these villages.

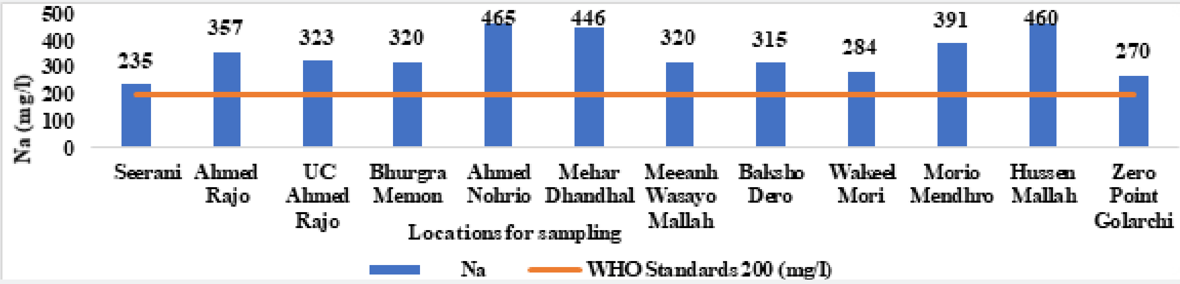

Figure 8: Ground water analysis of Sodium (Na) for different villages of Badin.

Sodium of ground water

The results regarding Sodium of the study area are shown in Figure 8. It can be notated from the figure that minimum Sodium was observed (235mg/l) in Seerani village that was observed 18% lower than the highest value and the maximum was observed (465mg/l) in Ahmed Nohrio village that was 133% higher than the lowest value. While the Sodium of groundwater in all other villages were more than the acceptable limits of WHO standards.

It can be seen from the graph all bars of collected samples from different villages crossed the permissible limits it means that the water samples were highly salted which shows the complete intrusion of seawater into these villages.

Potassium of ground water

The results regarding Potassium of the study area are shown in Figure 9. It can be notated from the figure that minimum Potassium was observed (6.2 mg/l) in Seerani village that was -48% lowest than the highest value and the maximum was observed (15mg/l) in Ahmed Nohiro village that was 25% higher than the lowest value. While the Potassium of groundwater in all other villages was within the safe limits as per WHO standards.

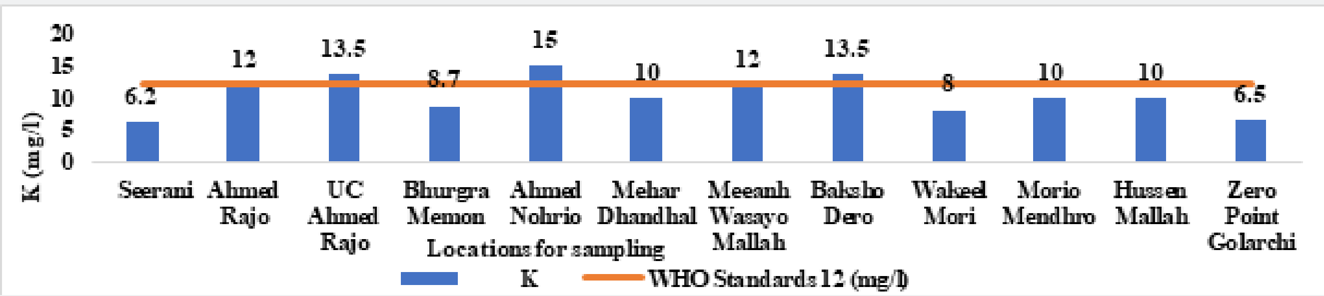

Figure 9: Ground water analysis of Potassium (K) for different villages of Badin.

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It can be seen from the graph all bars of collected samples from different villages crossed the permissible limits it means that the water samples were highly saline which shows the complete intrusion of seawater into these villages.

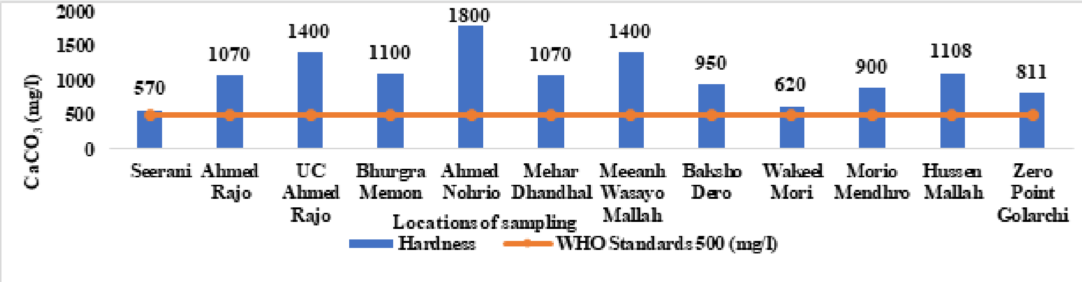

Figure 10: Ground water analysis for hardness (mg/l.) of water for different villages of Badin.

Hardness of ground water

The results regarding the hardness of the study area are shown in Figure 10. It can be notated from the figure that minimum hardness was observed (570mg/l) in Seerani village that was 14% lowest as compared to the highest value and the maximum was observed (1800mg/l) in Ahmed Nohiro village that was 260% highest than lowest value. While the Hardness of groundwater in all other villages crossed the acceptable limits as per WHO standards.

It can be seen from the graph the all bars of collected samples from different villages crossed the permissible limits it means that the water samples were highly saline which shows the complete intrusion of seawater into these villages.

Chloride of ground water

The results regarding the Chlorides of the study area are shown in Figure 11. It can be notated from the figure that minimum chlorides were observed (227mg/l) in Zero Point Golarchi and it was -9% lower than the highest value and the maximum value was observed (626mg/l) in Ahmed Nohiro village that was 150% higher than the lowest value. Whereas the chlorides of groundwater in all villages exceeded the acceptable limits as per WHO standards

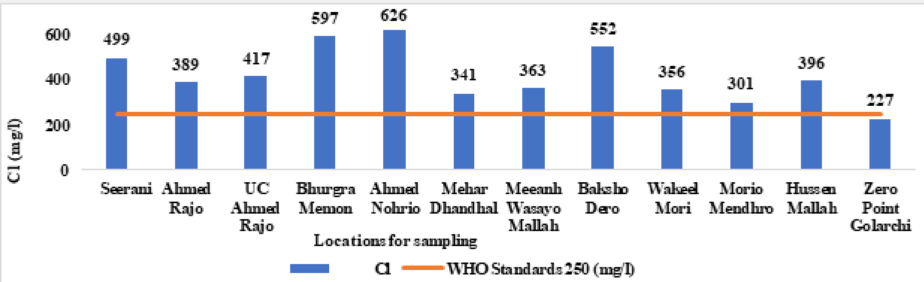

Figure 11: Ground water analysis for Chlorides (Cl) of ground water for different villages of Badin.

It can be seen from the graph the all bars of collected samples from different villages crossed the permissible limits it means that the water samples were highly saline which shows the complete intrusion of seawater into these villages.

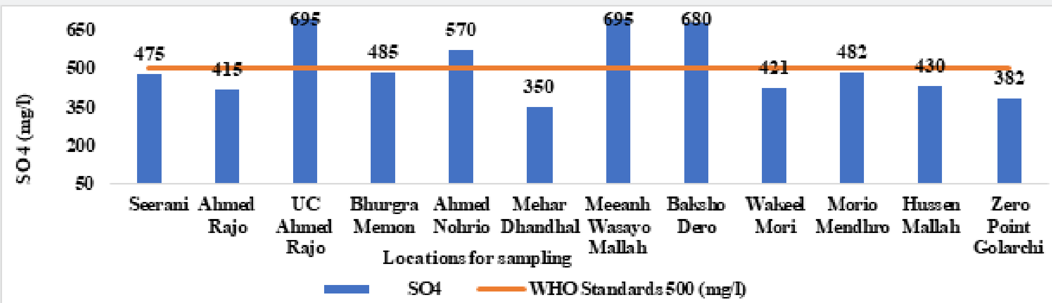

Figure 12: Ground water analysis of Sulfate (SO_4) for different villages of Badin.

Sulfate of ground water

The results regarding Sulfate of the study area are shown in Figure 12. It can be notated from figure that minimum Sulfate was observed (350mg/l) in Mehar Dhandhal Village that was -30% lowest than the highest value and the maximum value was observed (695mg/l) in In UC Ahmed Rajo and Meenah Wasayo

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Mallah villages that were 39% higher than the lowest value. While the Sulfate of groundwater in all other villages crossed the acceptable limits as per WHO standards.

It can be seen from the graph the all bars of collected samples from different villages crossed the permissible limits it means that the water samples were highly saline which shows the complete intrusion of seawater into these villages.

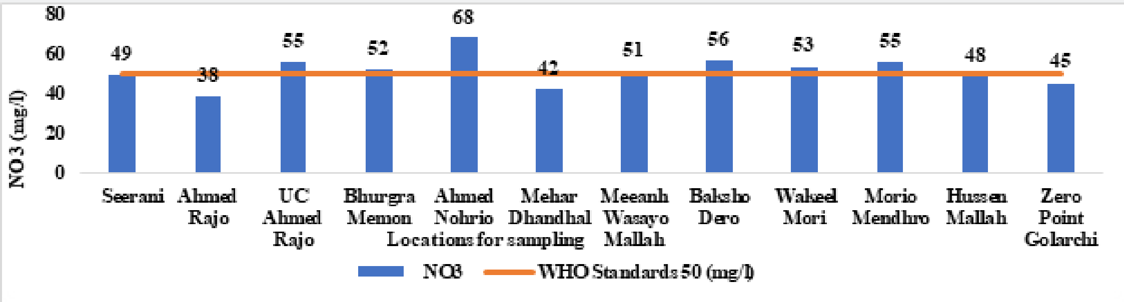

Figure 13: Ground water analysis of Nitrate (NO3) for different villages of Badin.

Nitrate of ground water

The results regarding the Nitrate of the study area are shown in Figure 13. It can be notated from the figure that minimum Nitrate was observed (38mg/l) in Ahmed Rajo village that was -24% lower than the highest value and the maximum was valued was observed (68mg/l) in Ahmed Nohiro village that was 36% higher than the lowest value. While the Nitrate of groundwater in all other villages exceeded the acceptable limits as per WHO standards.

It can be seen from the graph all bars of collected samples from different villages crossed the permissible limits it means that the water samples were highly saline which showed the complete intrusion of seawater into these villages.

Fluoride of ground water

The results regarding Fluoride of the study area are shown in Figure 14. It can be notated from the figure that minimum Fluoride was observed (0.47mg/l) in UC Ahmed Rajo village that was -51% lower than the highest value and the maximum was observed (1.56mg/l) in Ahmed Nohiro village that was 45% higher than the lowest value. While the Fluoride of groundwater in all other villages were above the acceptable limits as per WHO standards.

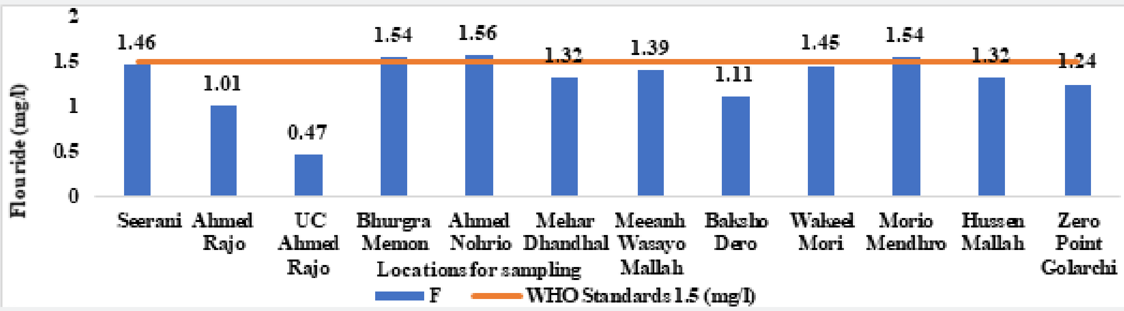

Figure 14: Ground water analysis of Fluoride (F) for different villages of Badin.

It can be seen from the graph all bars of collected samples from different villages crossed the permissible limits it means that the water samples were highly saline which shows the complete intrusion of seawater into these villages.

Microbiological contaminants

a) The microbiological contaminants were analyzed in the samples of the research area and were collected and analyzed by the kit method.

b) The biological and other living organisms were not found; therefore, it was negligible.

c) The microbiological parameters were within the safe limits.

Discussion

Groundwater usually appears clear and clean, the soil naturally filtered particles. But then, in coastal zones Natural and man-made chemicals can be found in underground water, by means of carbonates, bicarbonates and the manganese are dissolved and can be found later in high concentrations in groundwater. The results of the investigation demonstrated that the color, Odor, pH, of groundwater samples of the study area, were within acceptable levels for human utilization as per WHO. Whereas TDS, Mg, Na salts were high in all water samples of the study area as per WHO standards. The selected areas of district Badin were free from arsenic problem. These results were compared with the discoveries are upheld by Mahessar

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[6], which declared that the odor and pH were safe for drinking according to WHO limits.

PH: The pH values of all the water samples from selected villages of Badin (Figure 2) were under permissible limit. Similarly, in a previous report, it was found that the pH of all water samples was (7 to 7.6) of district Badin areas Mahessar [6]. High pH causes a bitter/ acidic taste [7].

Electrical conductivity (EC): The EC of collected water samples were (592%) higher than the allowable limit of water as per the recommendation of WHO. The electric conductivity of water bodies ranged from 500 to 18,700µS/cm, showing that the samples were high in soluble salts to the extent that almost all samples (261) near the coastal areas collected from wells excavated and hand/motor pumps exceeded the limit of 500µS / cm [8].

Total Dissolved Solids: The results also show that TDS values were 506% higher than permissible limit (1000mg/l), in all the selected water samples of Badin. Similarly, Mahessar [6] and Memon [8] said 47% of water samples in Taluka Fazul Rahoo were found unfit for drinking due to higher TDS values than the permissible limit set by WHO.

Chloride: Chlorides may be due to the presence of sodium in drinking water present at high concentrations. Often, the spread of seawater intrusion, minerals, industrial and domestic wastes Mowforth [7]. In the case of chloride content, the values of Chloride were observed (150%) higher than the allowable limit as per the recommendation of WHO. Similarly, 47% of water samples of Taluka Fazul Rahoo were unfit for drinking water due to higher chloride content than the permissible limit [6].

Sulfate: High concentrations of sulfate may occur as a result of seawater intrusion, mineralization, and household waste. Sulfate was observed (39%) higher than the allowable limit of water as per the recommendation of WHO. In the same way, Mahessar [6] determined in Taluka Badin, sulfate was (37%) higher than the permissible limit.

Bi-Carbonate: In the selected villages of Badin, Bi-Carbonates was observed higher than the allowable limit of water as per WHO. Similarly, in a previous report, it was found that all the water samples of district Badin areas were free from Bi carbonates, hence, were under the permissible limit [6].

Hardness: The result of ions dissolved in water; reported as the concentration of calcium carbonate. Calcium carbonates are derived from dissolved limestone or discharges from operating or abandoned mines. According to WHO, the hardness of drinking water should not exceed from 500mg/l. The results of water samples of selected areas of Badin show that Hardness of water were found (260%) higher than the permissible limit. As reported by Mahessar [6], the Hardness of water of District Badin was beyond the permissible limit.

Fluoride: Fluoride was observed (45%) higher than the allowable limit of water as per the recommendation of WHO. In the same way, Mahessar [6], reported that in Taluka Badin, fluoride of water samples of Fazul Rahoo village found higher than the permissible limit whereas fluoride content of water samples of other villages of Badin was under the permissible limit. Mowforth [7] said High level of Fluoride causes bone disorders (bone and joint calcification) at very high levels and reduces the incidence of tooth decay, but high levels can stain or damage the teeth. It stated the same in the guideline for drinking water [9].

Nitrate: Are considered non-cumulative toxins. High concentrations of nitrates can cause potential health risks such as methemoglobinemia or 'blue-baby syndrome' especially in pregnant women and infants fed with bottles, respectively Nkansah [10]. According to my results, nitrate was observed 36% higher than the WHO limits.

Overall the drinking water samples of coastal areas of district Badin is not safe and unfit for human consumption. Present results warn that the coastal zone needs to be provided safe drinking water which is a fundamental right of people of the area for their health and environment [11].

Conclusion

According to the results of the physical-chemical parameters of groundwater samples such as pH, Electrical Conductivity, Color, Odor, Turbidity, Alkalinity, Bicarbonates, Calcium, Magnesium, Sodium, potassium, Hardness, chloride, Sulfate Nitrate, Fluoride. The levels of all the groundwater samples were above the permissible limit. It is concluded that there is presence Seawater intrusion and the water was very saline and unsafe for drinking.

A short-term solution can be very simple: a freshwater injection in Indus River can restore life and property. "We have taken several studies, including that of the IUCN (International Union for the Conservation of Nature), which suggest that a discharge of 35 million hectares of water (MFA), 27MFA and even 10AFS in the delta could help reduce sea intrusion.

According to Pakistan's Water Apportionment Accord of (1991), water was apportioned to Punjab at 37% as opposed to 48.92%, a decrease of 11.92%. For Sindh, balance water was also apportioned at 37%, as opposed to 42.64%, a decrease of only 5.64%. Chairman of IRSA confirmed that water is not being shared in accordance with Water Accord.

Recommendation

There is urgent need to work out detail plan for sustainable development of safe drinking water to the coastal zone.

a) It is suggested to develop an alternative plan for groundwater recharge and water quality through rain harvesting and micro filtration treatment.

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b) The reason of the seawater intrusion is cause of less irrigation water availability at downstream of Kotri barrage.

c) It is necessary to set up a groundwater abatement system to prevent occurrence of saltwater on surface of groundwater or fresh groundwater.

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