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Research Article

The Relations Between Concentration of Iron and the pH Ground Water (Case Study Zulfi Ground Water)

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Abstract: The contamination of groundwater has major complications on the environment and can pose serious threat to agriculture and human health. However metals like magnesium, calcium, iron and manganese are necessary to sustain the vital plants function in trace amounts. Therefore World Health Organization has approved the treatment of water if concentrations of iron is higher than 0.3mg/L The aim of this research is to investigate the relationships between concentration of iron and the levels PH of ground water. Thirty five samples were collected from different 10 wells Groundwater in Zulfi Town, two samples from treated water. Water from the ground water is used extensively in Zulfi province for urban and rural water supply, agriculture, and industry. In all well the concentrations of iron was found to be higher than 0.3mg/L, and pH is greater than 7 except in in three wells. So we expect iron bacteria growth.

Keywords: pH of Water, Iron, Groundwater, Zulfi Province, Iron Bacteria Growth, World Health Organization, Arid Areas

1. Introduction

Groundwater is the main resource of drinking water in arid areas, which is also used in domestic consumption and irrigation. (Switzman, H.P. Coulibaly, and Z. Adee 420–438, (2015), (Kim, K-H., S-T. Yun, B. Mayer, J-H. Lee, T-S. Kim, H-K. Kim, 199: 369–381 (2015)). more than 5 million people died every year In developing countries due the diseases associated of Water born diseases (UNESCO, 2007), the precious gift of nature to human being is going to be polluted day by day with increasing urbanization. Ground water is an important source of drinking water for humankind. The water pollution by heavy metals has become a question of considerable public and scientific concern in the light of the evidence of their toxicity to human health and biological systems (Anazawa et al., 2004). Heavy metals receive particular concern considering their strong toxicity even at low concentrations (Marcovecchio et al., 2007). They exist in water in colloidal, particulate and dissolved phases (Adepoju - Bello et al., 2009) with their occurrence in water bodies being either of natural origin (e.g. eroded minerals within sediments, leaching of ore deposits and volcanism extruded products) or of anthropogenic origin (i.e. solid waste disposal, industrial or domestic effluents) (Marcovecchio et al., 2007). Some of the metals are essential to sustain life-calcium, magnesium, potassium and sodium must be present for normal body functions. Also, cobalt, copper, iron, manganese, molybdenum and zinc are needed at low levels as catalyst for enzyme activities (Adepoju-Bello et al., 2009).

Iron is metallic element present in many types of rock. Iron has the symbol “Fe” iron is commonly found in water and are essential elements required in small amounts by all living organisms. Concentrations of iron in groundwater are often higher than those measured in surface waters.

pH is the concentration of hydrogen ions. The concentration is calculated by the negative logarithm of the hydrogen ion (H+) concentration, i.e. the less free hydrogen ions the higher the pH level. The pH scale goes from 0 to 14 with 7 being neutral. Anything below 7 is considered acidic and anything above 7 is considered alkaline or basic. Marianne Metzger (2005). Higher pH prevents the corrosion and contamination from pipes Ahmad, M. and Bajahlan 2009. The World Health

Organization has approved the treatment of water if concentrations of iron is higher than 0.3mg/L. Fawazy G et al. (2016). In general, a water with a low pH (< 6.5) could be acidic, soft, and corrosive. Therefore, the water could leach metal ions such as iron, manganese, copper, lead, and zinc (Brian Oram, PG) (http://www.water-research.net)

Iron being the fourth most abundant element and second most abundant metal in the earth's crust is a common constituent of ground water. (SARO J KUMA R SHARM A 2001)

The presence of iron in Ground water is generally attributed to the dissolution of iron bring rocks and minerals. (FaustandAl y1998)

Iron may be insoluble (ferric hydroxide), soluble (ferrous bicarbonate), the iron atoms are also reduced from Fe^{3+} to Fe^{2+}. The most dominant form of dissolved iron is the soluble Fe^{+2} under the pH range of 5 to 8. When groundwater is pumped up to the surface it gets into contact with air (O_2) which enters the solutions and starts the oxidation process that releases carbon dioxide (CO_2) from the groundwater to the atmosphere. When this happens, the pH values are increased and hence the Fe^{2+} and Mn^{2+} are changed into the insoluble Fe^{3+} mineral. (Mansoor Ahmad, 2012). For Insoluble the water can appear rusty or yellowish in color. This happens because the iron is being oxidized by the atmosphere and forming ferric hydroxide. For Soluble iron in the water will appear clearly, but by time the iron will oxidize into particulate. Organic iron is combined with an acid, which can be clear, but usually has a yellowish-to-red color. Colloidal iron refers to very fine iron particles held in solution so the water appears discolored. Iron bacteria utilize iron as a nutrient source and can present significant clogging problems. Iron bacteria can grow enough to block pipes and clog well screens within weeks. Iron bacteria growth is very dependent upon the pH level, occurring over a range of 5.5 to 8.2 with 6.5 being the optimum level. [4]. These bacteria are not posing any health threat, but they can cause red brown slime in toilet tanks and can cause clogging of water systems. (Wilson et al 1999). There is another problem associated with iron and manganese in water is iron and manganese bacteria. light or dark conditions (Wilson et al., 1999). In Saudi Arabia drinking water is mainly obtained from desalinated seawater, ground water from wells (labdula'aly, Al., "Flouride 1997).

Iron bacteria:

Iron bacteria and Sulphur bacteria are small living organisms that naturally occur in soil, surface water, and groundwater. The Sources of Iron bacteria is naturally occurring organisms in the environment. Iron bacteria combine iron (or manganese), present in water, with oxygen. The iron bacteria may form large masses of an orangey-brown slime. There are two categories of sulphur bacteria: sulphur oxidizers and sulphur reducers. Sulphur-oxidizing bacteria chemically change sulphide present in drinking water into sulphate. Sulphur-reducing bacteria live in oxygen-deficient environments. They break down sulphur compounds present in water, producing hydrogen sulphide gas in the process. Of the two types, sulphur-reducing bacteria are the more common. Bacteria may be introduced during drilling or servicing of a well or when pumps are removed for repair and laid on the ground. Iron bacteria and sulphur bacteria can also exist naturally in groundwater. Iron bacteria are more common than sulphur bacteria, because iron is more abundant in groundwater. Iron bacteria and sulphur bacteria are not known to cause health problems or disease in humans. (http://www.novascotia.ca)

The objectives of the research described in this paper are investigate the relationships between PH levels of water and concentration of iron in Zulfi groundwater. And determine the effect of pH on the solubility of the water and biological availability of nutrients, specifically metals such as iron.

2. Materials and Methods

2.1. Study Area

Ground water samples were collected from wells (n=10) located in the Zulfi province in Riyadh region. Zulfi is located 26.30 latitude and 44.82 longitude and it is situated at elevation 620 meters above sea level. Zulfi has a population of 53,144 making it the 3rd biggest city in Riyadh. Fig. 1.

Fig. 1. *Zulfi Location.*

The sampling was carried out over four month period. The location of the wells was recorded using Geological Positioning System (GPS). The different locations of the sampled wells are shown in Fig. 2.

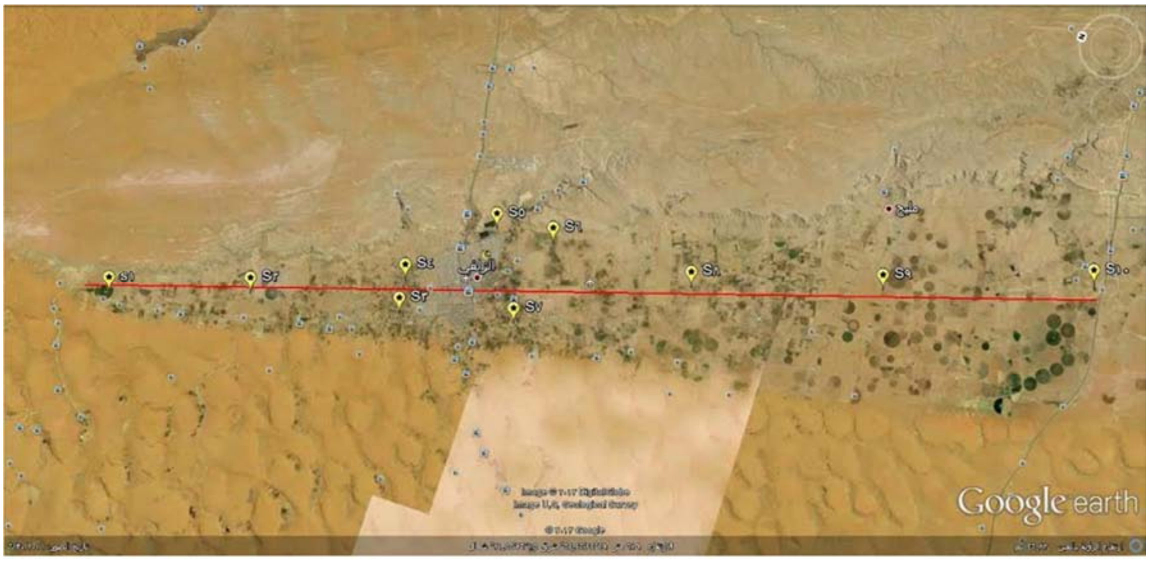

Fig. 2. *The locations of sampled wells.*

The sampled wells were private property. Many of the sampled wells were the main source of water for the local field.

2.2. Collection of Samples

Ground water samples were collected in 0.25-liter plastic bottles, which were previously thoroughly washed with tap water and rinsed with distilled water. These were immediately acidified to pH 2 with HNO in order to keep metals in solution and prevent them from adhering to the walls of the bottles.

All samples were transported to the laboratory in iceboxes and refrigerated at 4°C until analyzed.

Sampling protocol was designed in such a way that samples collected in one sampling schedule were analyzed in the shortest possible time Sample Analysis: Samples were analyzed for (Iron), and pH.

2.3. Measurement of pH

pH was Measure using a potentiometric method uses a pH meter, which includes a pH-measuring electrode (usually a glass electrode), a reference electrode, a high impedance voltmeter and a temperature-compensating device. The reference electrode is calomel, silver–silver chloride or some other reference electrode of constant potential.

2.4. Measurement of Iron

Using ICP-MS (Inductively Coupled Plasma-Mass Spectrometer): NexION 300D (Perkin Elmer, USA). The ICP-MS calibration was carried out by external calibration with the blank solution and four working standard solutions (100, 200, 300 and 400 µg/L) for Iron, starting from a 1000 mg/L single standard solutions for ICP-MS for trace elements.

3. Results

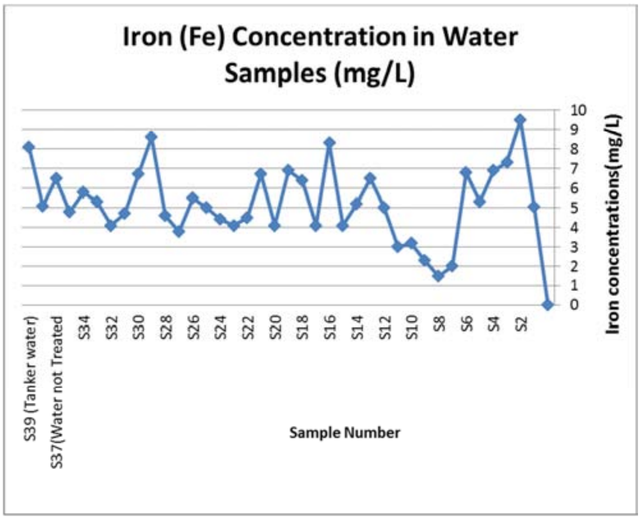

Fig. 3. *Iron (Fe) Concentration in Water Samples.*

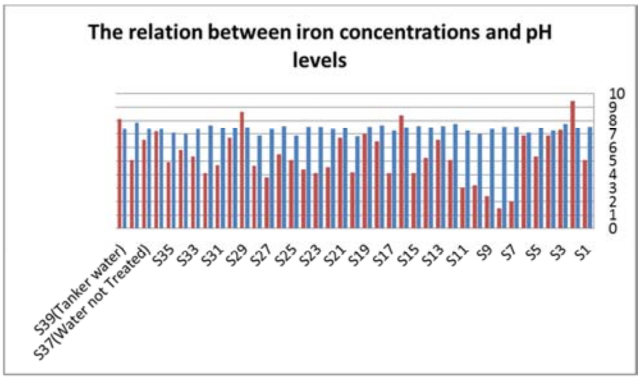

Fig. 4. *Concentration in Water Samples as a function of pH.*

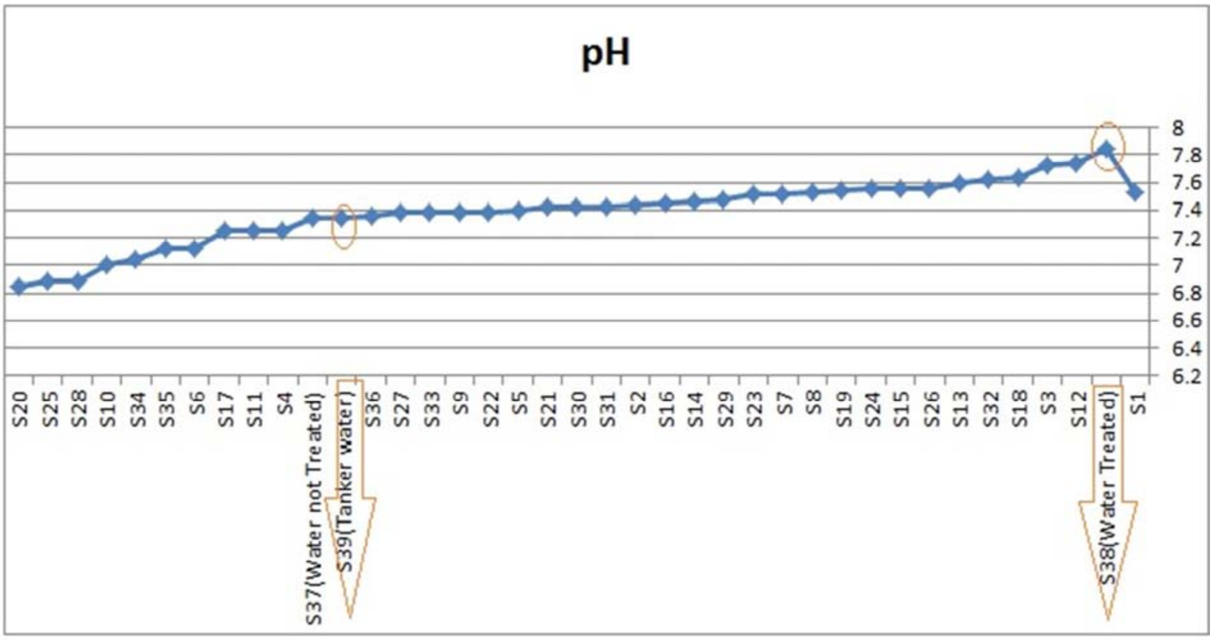

Fig. 5. *pH levels in Zulfi ground water (from the great levels to small levels).*

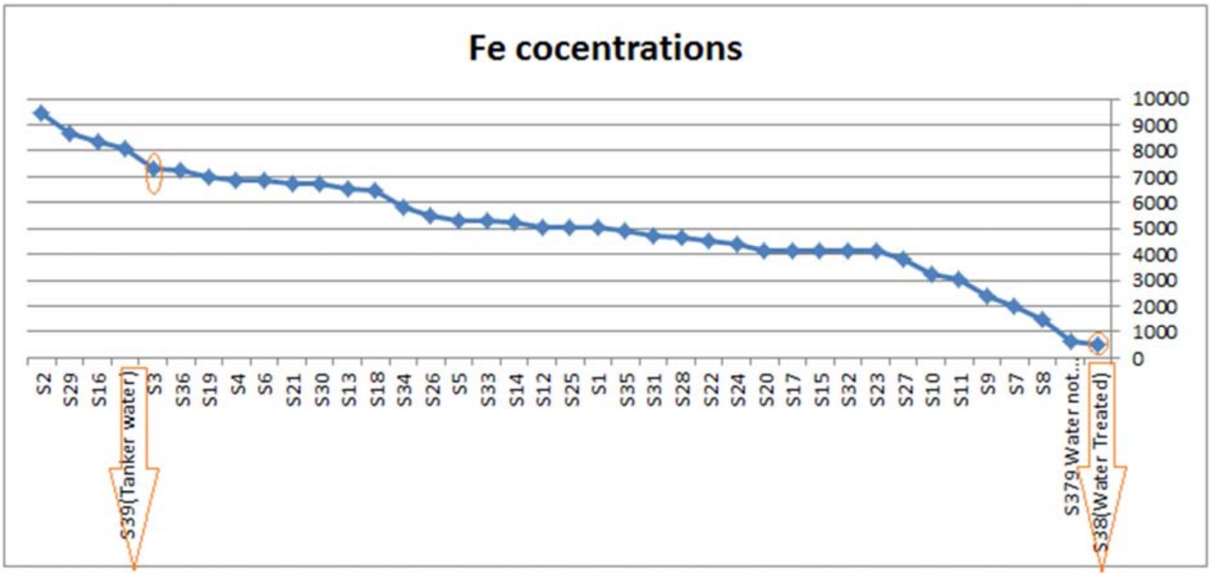

Fig. 6. *Fe concentrations in Zulfi ground water (from the great levels to small levels).*

Fig. 7. *Sample (S2): water color is brown.*

Fig. 8. *S20: clear water iron.*

4. Discussion

4.1. The Relationship Between pH-Value and Iron Concentration

The value of pH of water is very important, by which the solubility and biological availability of iron can determine (Worldwide Drilling Resource Marianne Metzger January 2005). The relationship between pH and iron values was constructed (Fig. 4), and it displays that the iron concentration increases with inecreasing pH values. Lower pH value below 6.5 tends to keep iron deposits in solutions and will typically cause corrosion problems (none of samples has pH value below 6.5).

From Fig. (7&8): water is acidic in sample S20 (pH is 6.85, iron concentration is 4.1mg/L). Fig. (4) which tends to keep minerals in solutions, but because pH levels are above 6.5 no problems corrosion (Marianne Metzger Wilson. A, Parrott. K, Ross B. 2005).

Water is in sample S2 (pH is 7.44, iron concentration is 9.4 mg/L). The iron Insoluble in water, because of high pH level. commonly called red water iron. Fig. (3). (Marianne Metzger Wilson. A, Parrott. K, Ross B. 2005).

4.2. Iron Bacteria Growth

The suitable values for growing iron bacteria of pH is ranges from 6.5 to 7.54, which can be introduced into a well or water system during drilling. The effects of iron bacteria are seen in surface waters as brown slimy masses on stream bottoms and lakeshores or as an oily sheen upon the water. Another problems occur when bacteria build up in well systems. In spite Iron bacteria in wells do not cause health problems, but they can reduce well yields by clogging screens and pipes (Figure (5). From figure (3): All wells the concentrations of iron is higher than 0.3mg/L, and pH is greater than 7 expect in three wells. The pH of most samples were considered alkaline or basic. So iron bacteria growth is expected. (Marianne Metzger Wilson. A, Parrott. K, Ross B. 2005).

5. Conclusions

Ranges of concentrations of iron in water can be predicted as a function of and pH. The concentration of iron in groundwater depends upon the amount of oxygen present in water. With the lack of oxygen, the iron atoms are also reduced from Fe^{3+} to Fe^{2+}. The most dominant form of dissolved iron is the soluble Fe^{+2} under the pH range of 5 to 8.

Iron bacteria growth is very dependent upon the pH level, occurring over a range of 5.5 to 8.2 with 6.5 being the optimum level so it expected in all samples.

In Zulfi ground we found most of well have pH is greater than 7 except in three wells (S20, S25, and S28).

In spite of the pH of samples S23 and S32 is 7.25 and 7.62 respectively figures (5, 6), the concentration of iron in the samples is 4.1(less concentrations), this because the samples were taken from treated water.

Recommendations

It recommended that more study for:

Iron bacteria growth in this samples.

Several techniques such as: Phosphate treatment for Low levels of dissolved iron at combined concentrations up to 3 mg/l, Ion exchange water softener

Low to moderate levels of dissolved iron, at less than 5 mg/l concentrations, Oxidizing filter

An oxidizing filter treatment system is an option for moderate levels of dissolved iron and combined concentrations up to 15 mg/l, and Aeration followed by filtration

High levels of dissolved iron at combined concentrations up to 25 mg/l must applied to remove iron from groundwater. (http://www.water-research.net).

Because all the concentrations of iron is higher than 0.3 mg/L.

The most common approach to control of iron bacteria is shock chlorination. It is almost impossible to kill all the iron bacteria in your system. They will grow back eventually so be prepared to repeat the treatment from time to time. If bacteria re-growth is rapid, repeated shock chlorination becomes time-consuming. Continuous application of low levels of chlorine may be less work and more effective. An automatic liquid chlorine injector pump or a dispenser that drops chlorine pellets into the well are common choices. Chlorine rapidly changes dissolved iron into oxidized (colored) iron that will precipitate. A filter may be needed to remove oxidized iron if continuous chlorination is used to control iron bacteria.

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