

Appraisal of Groundwater Quality in Parts of the Benin Formation in Imo River Basin, Southeastern Nigeria.

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ABSTRACT

A hydro-geochemical survey was undertaken in parts of Imo River Basin, Southeastern Nigeria, particularly in the geologic formation of Benin, to assess the quality of groundwater. Nineteen samples of groundwater were obtained from various boreholes in the study area and subjected to physico-chemical analysis using standard laboratory techniques. The study was aimed at the assessment of the groundwater quality indicators namely: pH, electrical conductivity (N), phosphate (PO_4), sulphate (SO_4), nitrate (NO_3^-), and total dissolved solids (TDS).

The result shows low pH values in the following areas: Ahiaba Okpuala (BH4); Iheorji-Isiala Ngwa (BH7); Ohanze (BH13); Obohia Road Aba (BH14); Ngwa Road Aba (BH15); Orpet PH Road Aba (BH16); Azikiwe Road, Aba (BH17); Brass Street Aba (BH18); Clifford Road Aba (BH19); Ogbor Hill Aba (BH20); Emekuku (BH24); and Nguru (BH25). Their pH values are below the acceptable range of 6.5-8.5, which indicates acidity. The acidity probably results from carbonic acid derived from the solution of CO_2 from both the atmosphere and the decomposition of plant materials in the soil zone.

(Keywords: acidity, groundwater quality, hydro-geochemical, Imo River basin, physico-chemical)

INTRODUCTION

Water is essential for livelihood as well as socio-economic development of any community. Many communities in Nigeria, especially in the Imo River Basin area rely on surface and groundwater for both domestic and agricultural water supplies. Groundwater pollution is a growing environmental problem, especially in developing countries. Many major cities and small towns in Nigeria depend on

groundwater for water supplies, mainly because of its abundance, stable quality and also because it is inexpensive to exploit. However, the urbanization process threatens the groundwater quality because of the impact of domestic and industrial waste disposal. This results in aquifer deterioration, since some of these waste products, including sewage and cesspool may be discharged directly into the aquifer system. Water soluble wastes and other materials that are dumped, spilled or stored on the surface of the land or in sewage disposal pits can be dissolved by precipitation, irrigation waters or liquid wastes and eventually seep through the soil in the unsaturated zone to pollute the groundwater. Once contaminated, it is difficult, if not impossible, for the water quality to be restored. Thus constant monitoring of groundwater quality is needed so as to record any alteration in the quality and outbreak of health disorders.

Groundwater quality depends, to some extent, on its chemical composition which may be modified by natural and anthropogenic sources (Wadie and Abuljalil, 2010). Rapid urbanization, especially in developing countries like Nigeria, has affected the availability and quality of groundwater due to waste disposal practice, especially in urban areas. Once groundwater is contaminated, its quality cannot be restored by stopping the pollutants from source (Ramakrishnaiah et al., 2009). As groundwater has a huge potential to ensure future supply of water, it is important that human activities on the surface do not negatively affect the precious resource (Sarukkalige, 2009).

Poor environmental management creates havoc on the water supply and hygiene and undermines public health [4] (Okoro et al., 2009). Tay and Kortatsi emphasize on the importance of groundwater globally as a source for human consumption and changes in quality with

subsequent contamination can, undoubtedly, affect human health (Tay and Kortatsi, 2008).

Acidified groundwater issues have been reported from many parts of the world particularly in North America and Europe (Hultberg and Wenbald, 1980; Appelo et al., 1982; Grivall et al., 1986). Groundwater in most hard-rock aquifers are also known to be vulnerable to quality problems that may have serious impact on human health (Smedley, 1995). The rocks are often carbonate-deficient and give rise to poorly buffered groundwater (acidic groundwater) that encourages the dissolution of elements such as Al, Mn, Be, and Fe from most minerals if they are present in the rock matrix into the groundwater and make the groundwater unsafe for drinking (Kortatsi, 2003). Acidity of groundwater can cause corrosion problems leading to high maintenance costs and shortened life of hand pumps and accessories. It can also lead to high metal concentrations in the borehole that may cause aesthetic problems and, in extreme cases, physiological problems.

GEOLOGY OF THE STUDY AREA

Figure 1 shows the location map of the study area in the Imo River Basin. The study area (Figure 2) lies between latitudes 5°05'N and 5°37' and longitudes 7°00' and 7°30'.

The Benin Formation (Miocene to Recent) covers more than half of the area of the Imo River Basin. It consists of sands, sandstones, and gravels, with intercalations of clay and sandy clay. The sands are fine-medium-coarse grained and poorly sorted (Whiteman, 1982; Uma and Egboka, 1985). Petrographic study on several thin sections (Onyeagocha, 1980) show that quartz makes up more than 95% of all grains, but Asseez (1976) and Avbovbo (1978) indicated a possible presence of more percentage of other skeletal materials including feldspar. This formation has very low dip to the south and south-west. The youngest deposits in the basin are alluvium of Recent age found mainly at the estuary of the Imo River at the Atlantic Ocean and on the flood plains of the river (Onwuegbuche, 1993).

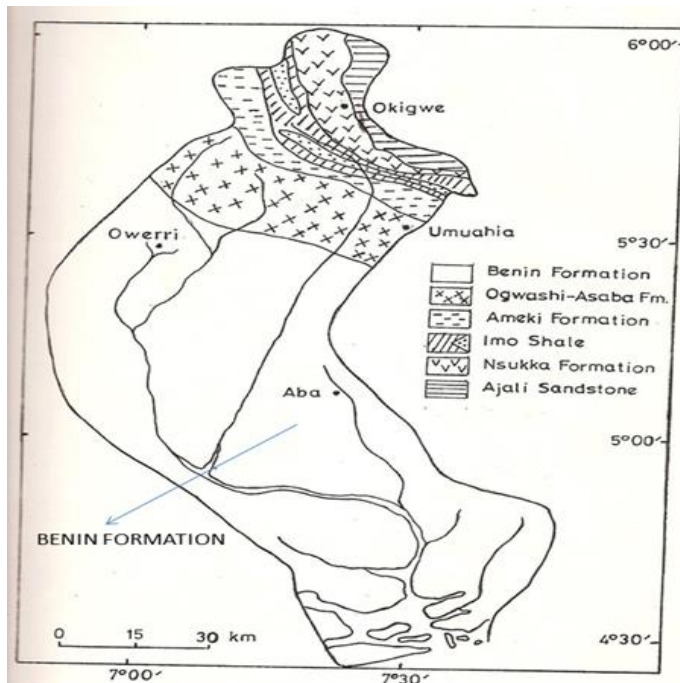


Figure 1: Geology Map of Imo River Basin (Uma, 1989).

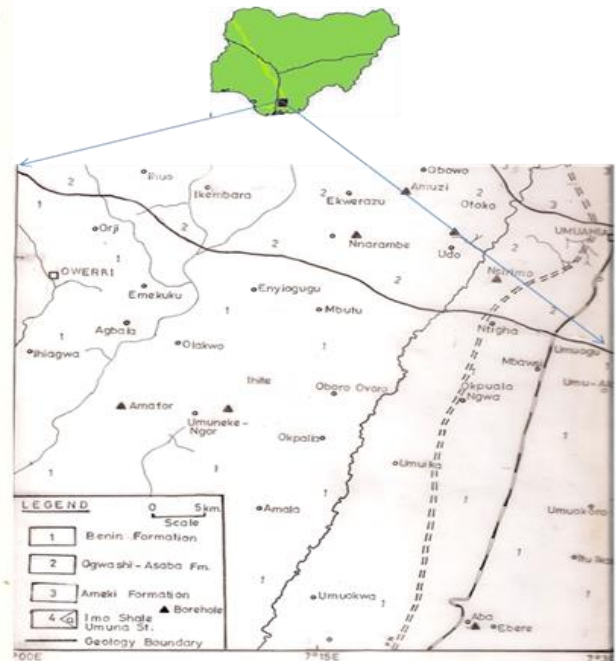


Figure 2: Map of the Study Area.

The Imo River Basin has a large amount of recharge; estimated at 2.5 billion m³ per annum, coming mainly from direct infiltration of precipitation. Average annual rainfall is about 2000mm (Onwuegbuche, 1993). The Benin Formation is by far the most aquiferous unit, consisting mainly of massive continental sands, sandstones, and gravels. It has a very extensive deep unconfined aquifer which covers more than half of the Imo River Basin. The aquifer consists of thick complex interbedded units of fine, medium and coarse-grained quartz sands and gravels (Uma, 1989).

MATERIALS AND METHODS

Investigations of the pollution status of groundwater in the study area were conducted recently by collecting water samples from boreholes in different locations in the study area.

Water samples from 19 randomly selected boreholes in the study area were analyzed for chemical quality at the UNICEF Water Project,

Owerri, and Imo State Environmental Protection Agency, respectively. The result was geo-processed to obtain groundwater quality maps showing the spatial variation of pH, electrical conductivity, sulphate, phosphate, total dissolved solids (TDS), salinity, and nitrate, respectively.

The samples were stored in a sterilized 250ml bottles and then taken to the laboratory for analysis. The electrical conductivity, total dissolved solids, Nitrate, sulphate, phosphate and salinity were determined using a HA-CH 44600-00 Conductivity/TDS meter at a temperature of 20°C. These samples were refrigerated and analyzed within 24 hours. All plastics and glass wares utilized were pre-washed with detergent water solution, rinsed with tap water and soaked for 48 hours in 50% HNO₃ then rinsed thoroughly with distilled-deionized water. They were then air-dried in a dust free environment. The pH was determined using a HACH sensor 3 pH meter. The turbidity was determined using a spectrophotometer. The result is presented in Table 1.

Table 1: Groundwater Quality Data from the Study Area.

S/N	BOREHOLE NUMBER	LOCATION	COORDINATES		pH	ELECTRICAL CONDUCTIVITY (µs/cm)	TDS (mg/l)	NITRATE (mg/l)	SULPHATE (mg/l)	PHOSPHATE (mg/l)	SALINITY	TURBIDITY (JTU)
			LONGITUDE	LATITUDE								
1	BH4	AHIABA OKPUALA	7.36663	5.35977	5.65	59	30	0.300	2.00	0.12	1.1	12
2	BH7	IHEORJI	7.37313	5.36432	5.80	42	21	0.100	1.00	0.05	2.8	5
3	BH13	OHANZE	7.43263	5.13525	6.18	84	42	0.200	1.00	0.13	3.2	5
4	BH14	OBOHIA RD. ABA	7.36028	5.08843	4.66	77	38	8.000	2.00	0.29	1.1	0
5	BH15	NGWA RD. ABA	7.36316	5.09992	4.42	72	36	10.50	5.00	0.21	8.1	7
6	BH16	ORPET, PH. RD. ABA	7.33995	5.07962	4.87	81	40	2.900	2.00	0.17	13.2	2
7	BH17	AZIKIWE RD. ABA	7.36282	5.10815	4.77	74	37	3.100	2.00	0.21	11.6	1.0
8	BH18	BRASS ST. ABA	7.35903	5.12765	4.84	73	37	3.900	2.00	0.14	0.6	6.0
9	BH19	CLIFFORD RD. ABA	7.38022	5.10322	4.52	74	37	8.100	2.00	0.10	4.8	9.0
10	BH20	OGBOR HILL ABA	7.38197	5.11518	5.28	74	37	0.200	3.00	0.22	2.3	11.0
11	BH22	AZARAEGBELU	7.15123	5.47239	7.60	18.5	19.4	42.000	0.00	--	2.6	10.0
12	BH24	EMEKUKU	7.10536	5.46816	5.00	96.2	42.0	0.500	0.02	0.20	0.8	--
13	BH25	NGURU	7.13174	5.37808	6.00	13.6	6.8	0.100	--	2.00	7.1	7.5
14	BH26	OKPUALA	7.25231	5.31544	6.70	12.5	6.2	2.000	--	1.50	6.5	7.0
15	BH32	ASSUMPTA, CATH., OWERRI	7.03044	5.48811	6.8	44.8	22.6	1.200	0.80	2.40	--	--
16	BH33	OFOROLA	6.92639	5.42279	6.5	94.1	47.0	0.100	--	--	16.5	--
17	BH35	MCC RD. OWERRI	7.09984	5.49849	7.3	181.6	91.6	13.200	--	0.85	13.2	10.0
18	BH38	OKWU NGURU ABOH MBAISE	7.23421	5.48464	6.5	36.2	19.0	0.300	0.01	--	11.5	0.5
19	BH55	UMUEZE OJI, ABOH MBAISE	7.22105	5.39933	6.5	36.8	18.5	0.100	--	--	2.06	0.0

RESULTS AND DISCUSSION

pH

Figure 3 shows the map of the spatial variation of pH in the study area. The result shows low pH values in the following areas: Ahiaba Okpuala (BH4); Iheorji-Isiala Ngwa (BH7); Ohanze (BH13); Obohia Road Aba (BH14); Ngwa Road Aba (BH15); Orpet PH Road Aba (BH16); Azikiwe Road, Aba (BH17); Brass Street Aba (BH18); Clifford Road Aba (BH19); Ogbor Hill Aba (BH20); Emekuku (BH24); and Nguru (BH25). The pH values are not within the acceptable WHO range for portable water (6.5-8.5) (WHO, 2011).

The acidity probably results from carbonic acid derived from the solution of CO_2 from both the atmosphere and the decomposition of plant materials in the soil zone. The acidity of the groundwater gives slight sour taste to drinking water and has also led to the mobilization of trace metals particularly iron, manganese, aluminum, and arsenic into the groundwater system, because of the corrosive effect of acidic water. It is the amount and type of dissolved minerals that give the groundwater its distinctive taste. Since

borehole supply is rarely treated, these trace metals end up in domestic supplies resulting in health implications and complaints. Acidic waters are typically low in buffering calcium minerals, but are high in dissolved carbon dioxide gas, which can cause the low pH or acidity.

Electrical Conductivity

The map of the spatial variation of electrical conductivity is shown in Figure 4. Electrical conductivity of water is used as an indicator of how salt-free, ion-free, or impurity-free the sample is; the purer the water the lower the conductivity (the higher the resistivity). The World Health Organization standard for acceptable electrical conductivity is $100\mu\text{s}/\text{cm}$. Pure water has an electrical conductivity of $5.5\mu\text{s}/\text{cm}$, which is a measure of the total dissolved solid (TDS), while rain water and ocean water have 5000 to $30000\mu\text{s}/\text{cm}$ and 45,000 to $60,000\mu\text{s}/\text{cm}$ respectively. Normal groundwater has a range of 100 to $2000\mu\text{s}/\text{cm}$ (Offodile, 2002). The values electrical conductivity in all areas within the study area fall within the WHO standard for electrical conductivity.

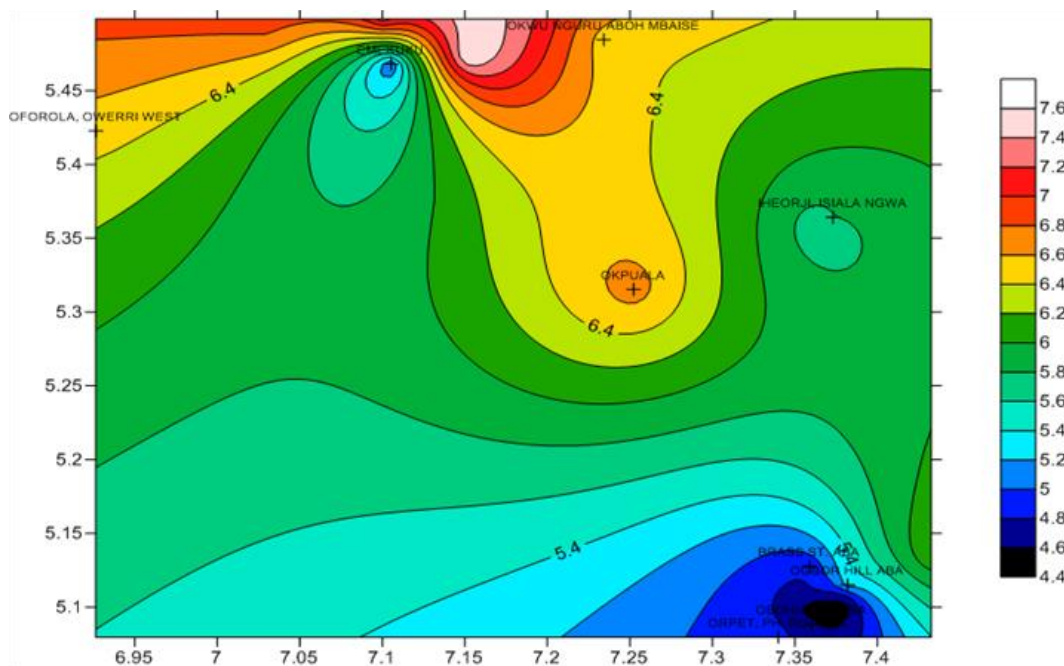


Figure 3: Spatial Map of pH in the Study Area.

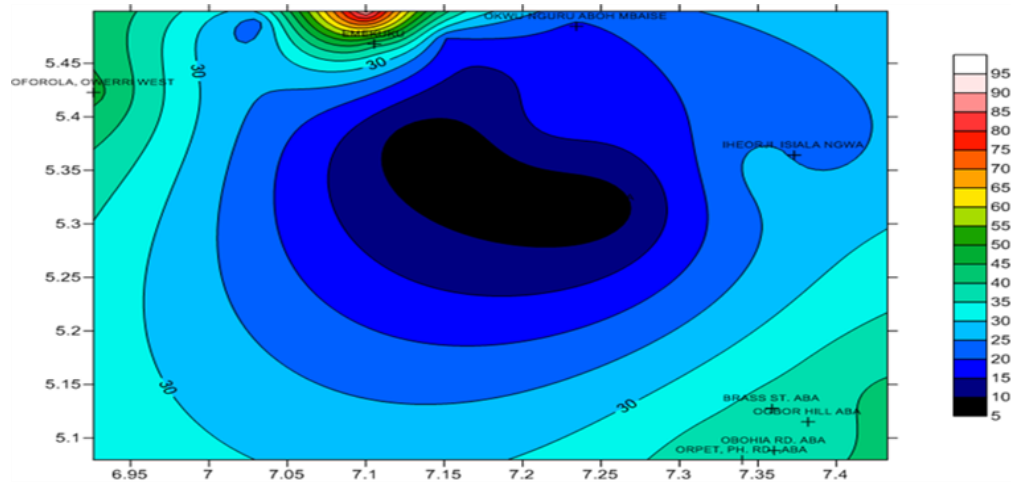


Figure 8: Map of Total Dissolved Solids in the Study Area.

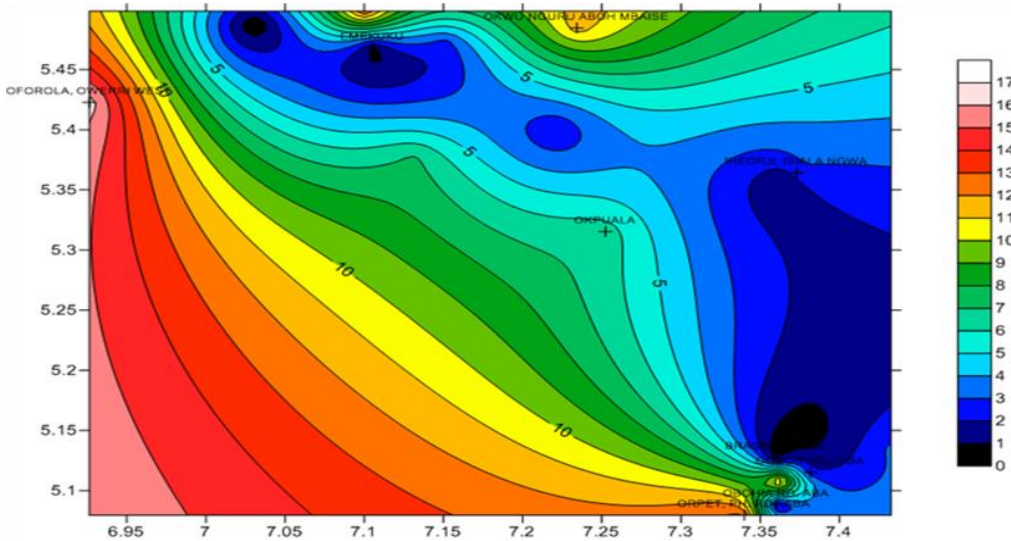


Figure 9: Map of Spatial Variation of Salinity in the Study Area.

Salinity

Figure 9 shows the map of spatial variation of salinity in the study area. The salinity indicates the presence of sodium chloride in the sample. It is generally soluble and essential to animals and man. However, in higher concentrations it inhibits plant growth, and can be harmful to man. The WHO standard for salinity of drinking water is 50mg/l. No location in the study area exceeded the WHO standard.

Turbidity

Figure 10 shows the map of the turbidity in the study area. Turbidity is the amount of cloudiness in the water. This can vary from a river full of mud and silt where it would be impossible to see through the water (high turbidity), to a spring water which appears to be completely clear (low turbidity). Turbidity can be caused by silt, sand and mud, bacteria and other germs, and chemical precipitates. It is very important to measure the turbidity of domestic water supplies, as these supplies often undergo some type of water treatment which can be affected by turbidity.

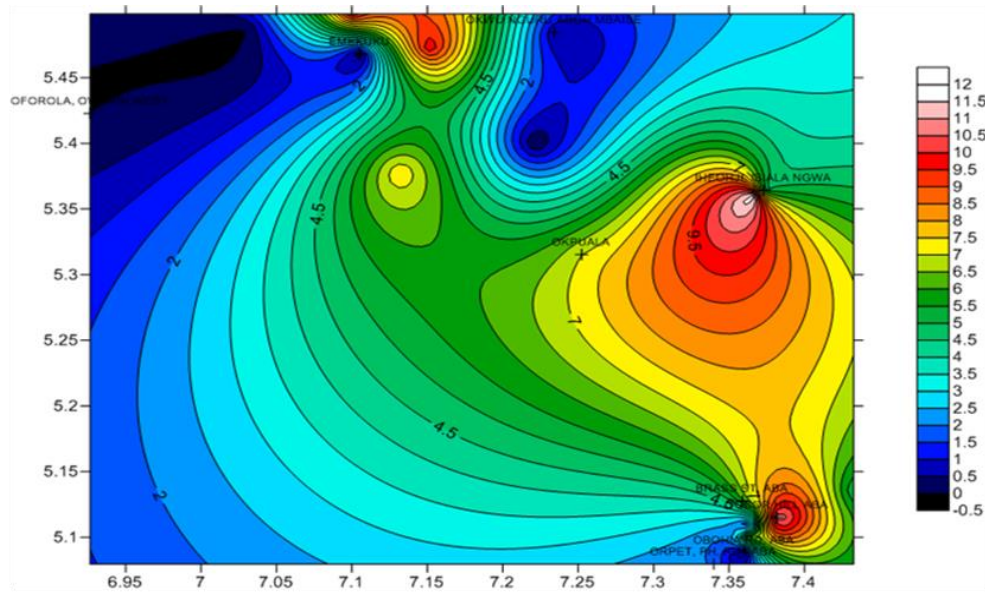


Figure 10: Map of Spatial Variation of Turbidity in the Study Area.

Turbidity was measured in nephelometric turbidity units (NTU), using a turbidity meter because of its accuracy. The map shows that most of the areas investigated are within acceptable WHO standard.

CONCLUSION

From the groundwater quality analysis, most of the groundwater quality parameters measured are within acceptable portable standards, except for the acidity of the groundwater at Ahiaba Okpuala (BH4); Iheorji-Isiala Ngwa (BH7); Ohanze (BH13); Obohia Road Aba (BH14); Ngwa Road Aba (BH15); Orpet PH Road Aba (BH16); Azikiwe Road, Aba (BH17); Brass Street Aba (BH18); Clifford Road Aba (BH19); Ogbor Hill Aba (BH20); Emekuku (BH24); and Nguru (BH25).

Virtually all groundwater comes from precipitation that soaks into the soil and passes down to the aquifer. Rainwater has a slightly acidic pH, therefore it tends to dissolve solid minerals in the soil and in the aquifer. Different rocks (e.g., sandstone, limestone and basalt) all have different minerals and therefore, groundwater in contact with these materials will have different compositions. Acidic waters are typically low in buffering calcium minerals, but are high in dissolved carbon dioxide gas, which can cause the low pH or acidity.

Calcite neutralizer tanks with natural, crushed and screened pure calcium carbonate easily neutralize acidic water from 6.0 to 6.9. Below 6.0 a blend of calcite and Corosex is recommended. Calcite is a crushed and screened white marble media, which can be used to neutralize acidic or low pH waters to a neutral, less corrosive effluent. Corosex is a specially processed hard, bead like magnesia, adapted for use in filters to neutralize acidity by increasing the pH. Common systems used to treat low pH include Calcite Neutralizer, calcite and Corosex Blend Neutralizer, Soda Ash Feed Pump Injection System. In neutralizer filters, acidic waters slowly dissolve the calcium and magnesium media on contact as the water flows through the filter, raising the pH of the water and increasing the alkalinity. This eliminates the effects of corrosive water chemistries and can help to prevent corrosion of piping and fixtures. Generally the lower the pH, the lower the hardness and alkalinity, and the higher the total dissolved solids will mean the water is more corrosive. Further studies can be undertaken to determine the amount and type of trace minerals present in the groundwater.

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