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RESEARCH ARTICLE

IRON AND MANGANESE IN GROUNDWATER AND THEIR IMPACT ON STRUCTURES:CASE OF A FEW LOCALITIES IN THE TAHOUA REGION (NIGER)

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Abstract

In Niger, some localities in the Tahoua region, groundwater is the main source of drinking water for the population. However, these waters are very loaded with Fe (II) and Mn (II), respectively exceeding the standard set by the WHO (0.3 mg / L and 0.1 mg / L). When these waters are in contact with the oxygen in the air, this degrades their aesthetic and organoleptic quality, but also that of structures and pipes. The objective of this study is to take stock of the presence of iron and manganese in water and their impact on the structures, which may justify the need for the creation of a treatment unit for their removal. Sampling was carried out at the level of the four localities. The pH was measured at the sites, total iron and manganese (II) are measured in the laboratory by colorimetry using a DR3900. The results show that in all the boreholes sampled, the concentration of total Fe varies from 1.231 mg / L to 6.295 mg / L, and that of Mn (II) from 0 mg / L to 0.97 mg / L. All of the structures and pipes that carry this water are completely damaged or blocked by a ferric deposit, identified by the DRX as a very poorly crystallized 2-Line ferrihydrite.

Introduction:-

In developing countries with an arid climate like Niger, the role of groundwater is all the more important as it is often the only source of drinking water supply and is therefore vital for the development of these countries (Travi, Y. 1993). Niger, faced with an ever-growing population which exerts enormous pressure on water resources, has to face a scarcity of surface water. This very worrying problem is pushing the authorities to seek new sources. In addition, groundwater, which represents a significant water reserve, constitutes an alternative to cope with this shortage. These groundwater are necessary to cover a large part of the population's water needs, however most of this groundwater, particularly in the region of Tahoua, has a high content of iron and manganese. Iron and manganese are essential in small amounts for all living organisms. However, overloading the human body with iron can lead to primary hemochromatosis (poor regulation of iron absorption by the intestine) and even liver cancer (risk of liver cancer). Manganese is an essential nutrient involved in the metabolism of amino acids, proteins and lipids, but in excess it can be a powerful neurotoxicant simultaneously or separately in water, iron and manganese are troublesome in waters intended for human consumption (Bouchemal, M. F., et al 2011). In groundwater, iron is often associated with manganese with which it has the property of co-precipitating, when the concentration of iron (II) and manganese (II) exceeds 0.3 mg / L and 0.1 respectively. mg / L, these two metal ions must be eliminated or reduced to concentration levels below the standards(WidedMejri. 2018) Soluble iron and manganese (II) present in water cause organoleptic problems, they stain laundry and adversely affect the appearance of these waters (Fakhfekh

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Hamdeni, R. 2017),(Doggaz, A et al 2018). Indeed, the presence of these elements in excess in the water causes the degradation of its quality and also promotes the degradation of storage structures, obstruction of pipes, seizing of valves, a drop in flow ...(Mouchet, P. 1992),(Dangeti, S et al 2017). In addition, their precipitation allows the proliferation of bacteria (Bin Jusoh, et al 2005), (Boukari, Y. et al 1988), (Montiel, A. et al 1990), (Lasm, T. et al 2008) and(Chaturvedi, S et al 2012).AThe objective of this work is to take stock of the knowledge and the quantitative presence of iron and manganese in the water of certain boreholes in the localities of the Tahoua region and their impact on the storage structures and pipelines which carry these waters, in order to justify the need to create a unit for their removal

Material and Methods:-

Sampling:

Sampling was carried out during the months of July 2018 and 2019 by following the protocol described by Rodier (Rodier J et al 2009). These samples are manual and are carried out at the head of the borehole. The water samples were collected in five localities in the Thaoua region namely Keita, Ibohamane, Illéla, Badaguichiri, and GuidanKadiSadaoua.

PH measurement in the field:

Field pH measurement was performed immediately after taking water samples, using a Mettler Toledo brand pH meter

Measurement of Iron and Manganese:

Total iron and manganese were determined in the laboratory spectrophotometrically using a DR3900.

Results and Discussion:-

Iron and Mn content in groundwater:

After analyzes of our samples, the results are shown in the table below.

Table:- Results of iron and manganese analyzes in the different samples.

Sites Settings	Keita	Ibohamane	Badaguichiri	Illéla Forage 1	Illéla Forage 2	GuidanKadi
pH	6,8	7,33	7,19	6,7	7,09	7,21
Total Fe (mg/L)	6,08	5,12	3,695	6,057	6,295	1,231
Mn^{2+} (mg/L)	0,97	0,78	0,3	0,5	0,5	0

After analysis, all our samples have a total iron concentration greater than the WHO limit value, respectively 6.08 for the Keita borehole, 5.12 for the Ibohamane borehole, 6.057 mg / L for F1 Illela, 6.295 mg / L for F2. For the Badaguichiri borehole the grade is 3.695 mg / L and for the GuidanKadi borehole the value is 1.231 mg / L. However, the Regulation respecting the quality of drinking water stipulates that "water intended for human consumption must, when it is made available to the user, meet drinking water quality standards, the concentration iron should not exceed 0.3 mg / L (World Health Organization, 2004). Here, all of our samples do not meet this water potability requirement. However, the presence of iron, generally accompanied by manganese according to the literature, could be linked to the geological nature of the terrain, or industrial pollution and also public landfills.

As for manganese too, all the samples analyzed show concentrations above the value set by the WHO with the exception of that of GuidanKadi where the concentration is zero. Thus the value of the concentration found in the samples varies from 0 mg / L to 0.97 mg / L.

Impact of the presence of iron and manganese on structures and pipelines:

Iron (II) is easier to oxidize by oxygen in the air than manganese according to the equation:

$$4Fe_{aq}^{2+} + O_2 + 10H_2O \rightarrow 4Fe(OH)_3 + 8H^+$$

Thus this oxidation process gives water an unpleasant appearance such as colorings or tastes and odors (Zogo, D. et al 2010). The figure below illustrates the consequences of iron and manganese on the structures and pipelines which carry water rich in these elements.

Figure 1:- Images of structures and pipes attacked by oxidation of ferrous iron and manganese.

X-ray diffraction characterization of deposits collected in water pipes:

We analyzed the solids recovered from the water pipes by X-ray diffraction. Figures 2 and 3 present the diffractograms of these solids, over an angle range from 0 to 100 ° 2θ, The mineralogical phase of these solids was determined using the files available in the database and only revealed the the exclusive presence of poorly crystallized 2-Line ferrihydrite, confirmed by data from the literature (He, J et al 2020) and (Rout, K. et al 2012)

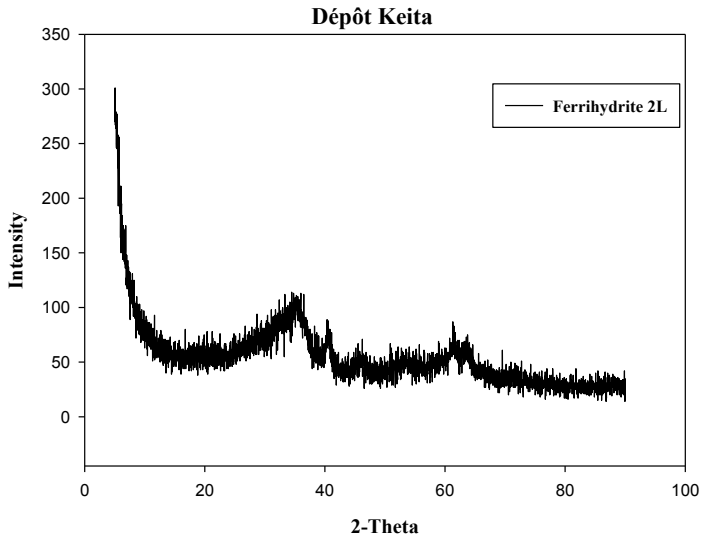

Figure 2:- X-ray diffraction of a deposit of iron recovered from a water pipe at Keita.

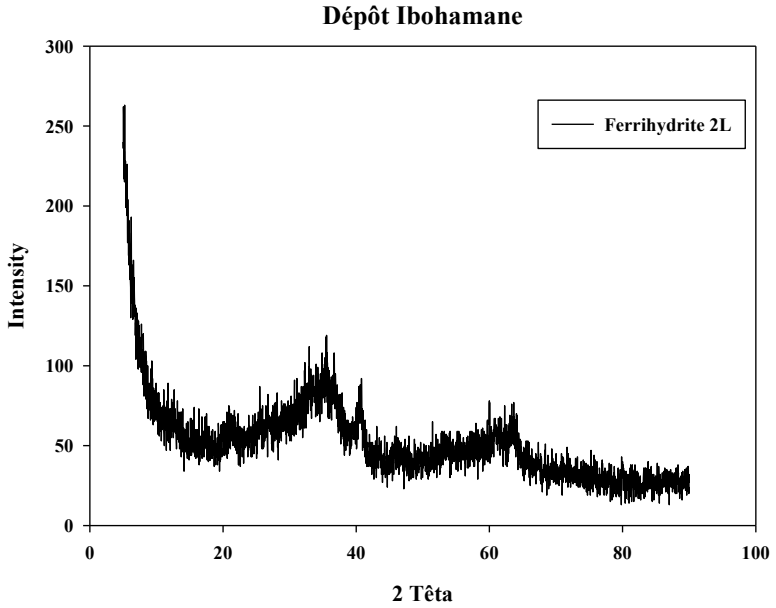

Figure 3:- X-ray diffraction of an iron deposit recovered from an Ibohamane water pipe.

Advantage of the creation of an iron and manganese removal unit:
On the one hand, the colossal economic losses due to the replacement of water storage facilities and structures generated by the oxidation of iron (II) and manganese (II) and on the other hand in rural areas, the operation of many boreholes and structures are threatened with disappearance due to contamination by iron (II) and manganese (II). Faced with this, there is an urgent need to create small units for their elimination, in order to improve the living conditions of these populations and to guarantee access to safe drinking water for all and sustainable management of water.

Conclusion:-

At the end of this study it emerges that the groundwater of Keita, IbohamaneBadaguichiri, Illéla, and GuidanKadi are characterized by a high iron and manganese content largely exceeding the WHO standards. The storage structures and the pipes that convey this water are completely scaled by deposits (2-Line ferrihydrite) from the oxidation-precipitation of these elements.

References:-

1. Travi, Y. (1993). Hydrogeology and hydrochemistry of aquifers in Senegal. Hydrogeochemistry of fluorine in groundwater (Vol. 95, No. 1). Persée-Portal of scientific journals in SHS
2. Bouchemal, M. F., Bouchahm, N., &Achour, S. (2011). Water quality of aquifers in the BISKRA region. Journal of Fundamental and Applied Sciences, 3 (1), 34-44.
3. WidedMejri Contribution to the study of the removal of ionic iron from water and the iron - calcium carbonate interaction
4. Fakhfekh Hamdeni, R. (2017). Performance of the hybrid precipitation / microfiltration system and of nanofitration in the elimination of iron for the purification of water (Doctoral dissertation, Lyon).
5. Doggaz, A., Attour, A., Mostefa, M. L. P., Tlili, M., &Lapicque, F. (2018). Iron removal from waters by electrocoagulation: Investigations of the various physicochemical phenomena involved. Separation and Purification Technology, 203, 217-225.https://doi.org/10.1016/j.seppur.2018.04.045
6. Mouchet, P. (1992). From conventional to biological removal of iron and manganese in France. Journal-American Water Works Association, 84(4), 158-167.
7. Dangeti, S., Roshani, B., Rindall, B., McBeth, J. M., & Chang, W. (2017). Biofiltration field study for cold Fe (II)-and Mn (II)-rich groundwater: accelerated Mn (II) removal kinetics and cold-adapted Mn (II)-oxidizing microbial populations. Water Quality Research Journal, wqrjc2017006.https://doi.org/10.2166/wqrj.2017.006

8. Bin Jusoh, A., Cheng, W. H., Low, W. M., Nora'aini, A., & Noor, M. M. M. (2005). Study on the removal of iron and manganese in groundwater by granular activated carbon. Desalination, 182(1-3), 347-35 https://doi.org/10.1016/j.desal.2005.03.022
9. Boukari, Y., Matejka, G., Parinet, B., & Simon, P. (1988). Balancing tropical waters: consequences for iron removal. Revue des sciences de l'eau / Journal of Water Science, 1 (4), 339-353. https: //10.7202/705016ar
10. Montiel, A., &Welte, B. (1990). Manganese in water-Removal of manganese in water by biological treatment. Revue des sciences de l'eau / Journal of Water Science, 3 (4), 469-481. https://doi.org/10.7202/705086ar
11. Lasm, T., Yao, K. T., Oga, M. S., Kouamé, K. F., Jourda, P., Kouadio, K. E., &Baka, D. (2008). Analysis of the physico-chemical characteristics of groundwater in proterozoic land region of the Tiassale area (Southern Côte d'Ivoire). European Journal of Scientific Research, 20 (3), 526-543
12. Chaturvedi, S., & Dave, P. N. (2012). Removal of iron for safe drinking water. Desalination, 303, 1-11.https://doi.org/10.1016/j.desal.2012.07.003
13. Rodier J., Legube B., Merlet N. and Collaborateurs (2009). The Water Analysis. 9th edition; Completely updated, Ed. Dunod, Paris, 1511 p.
14. World Health Organization, 2004. Guidelines for Drinking Water Quality, Recommendations, 3rd ed. World Health Organization, Geneva
15. Zogo, D., Bawa, L. M., Soclo, H. H., Djanéyé-Boundjou, G., &Atchekpe, D. (2010). Effect of pre-chlorination on the efficiency of iron and manganese removal from surface water by coagulation-flocculation using aluminiumsulphate: case of the Okpara dam in the Republic of Benin. International Journal of Biological and Chemical Sciences, 4(6).http://ajol.info/index.php/ijbcs
16. He, J., Xiong, D., Zhou, P., Xiao, X., Ni, F., Deng, S., ...&Luo, L. (2020). A novel homogenous in-situ generated ferrihydrite nanoparticles/polyethersulfone composite membrane for removal of lead from water: development, characterization, performance and mechanism. Chemical Engineering Journal, 124696.
17. Rout, K., Mohapatra, M., &Anand, S. (2012). 2-Line ferrihydrite: synthesis, characterization and its adsorption behaviour for removal of Pb (II), Cd (II), Cu (II) and Zn (II) from aqueous solutions. Dalton transactions, 41(11), 3302-3312.