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Experimental Study Iron Removal Groundwater South of Algeria (ILLIZI).

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ABSTRACT

The ground waters, which supply the city of Illizi, are loaded with iron according to the origin with the reservoir rocks and the nature of the grounds which surround the aquifer layer. This water is characterized also by a significant turbidity, due to the high rate of the precipitate of ferric iron, of rust color, resulting from the oxidation of ferrous iron in water. The presence of iron in the groundwater involves many nuisances, such as the deterioration of the organoleptic quality and the color of water (in the presence of iron, brownish discoloration with tendency of rust), the degradation of the distribution and storage woks (corrosion, filling) or the reduction in the effectiveness of the disinfection by consumption of oxidant. This work was carried out on the pilots of defferrization being in the neighborhoods of the city of Illizi. Our study is related to two treatment units: - The first device is based on a mechanism of natural Oxygenation by Tour of cascades - Decantation –Filtration (TDF). - The second device is based on a process of artificial Oxygenation by Aerators - Decantation –Filtration (ADF). The principal objective is to determine the characteristics of the pilots making it possible to obtain a greater effectiveness of the units, from the iron removal point of view. Measurement and analysis are related particularly to the total iron and the flow. Measurement and analysis concerns the taken water from the raw water entry in the unit to its exit. The obtained results show that the two tested processes are very effective in the drawdown of the iron contained in water: - First process (TDF) provides folding backs from 0.3 to 0.014 ppm. - Second process (ADF) provides folding backs from 0.39 to 0.026 ppm.

Keywords: groundwater, quality of subterranean waters, ferric-iron, natural Oxygenation, artificial Oxygenation, experimental aeration of defferrization.

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INTRODUCTION

Groundwater, serving the city of Illizi, is loaded with iron according to the origin of reservoir rocks. The turbidity of water; is a comprehensive measure that takes into account all subjects or colloidal or insoluble mineral or organic origin. Suspended particles exist naturally in water, such as silt, clay, organic materials and inorganic fine particles, plankton and other microorganisms (Health Canada, 2003). The reliability and optimizing the operation of urban sanitation systems require the development of pollution continuous assessment methods: the use of turbidity, for the assessment of water pollution, is positive and interesting through its permanent and immediacy (MARECHAL et al., 2001). Many physico-chemical techniques can be used for removal of turbidity of water. For example, turbidity can be reduced by chemically assisted filtration, slow sand, diatomaceous earth, membrane, or other filtration technique proven. Chemically assisted filtration process generally includes chemical mixing, coagulation, flocculation, sedimentation (or dissolved air flotation) and the rapid gravity filtration.

Aluminum salts and iron salts are the primary coagulant and the cationic and anionic polymers which are flocculation agents most commonly used; and which were used as filter media, with the nonionic polymers. In fact, the adsorption of metal ions in the colloidal particle surface changes the electro negativity of these suspensions and increases therefore the collision probability between the particles. The end result is an agglomeration of micro floc, then in larger flocks well Decantation (Bunker et al., 1995). Membrane separation techniques are physical methods of solid-liquid separation implementing selective membranes having pore diameters are between 0.1 and 10 microns, and thus allow retention of suspended particles, bacteria, and indirectly colloids, and certain ions after mounting the latter on larger particles obtained by complexassions, precipitation or flocculation (Berland and Juery., 2002; Choo et al, 2004) .However, these membrane processes employ membranes manufactured, for most of them, from organic polymers (cellulose acetates, poly sulphones, polyamides, etc.) which have disadvantages depending on their composition based on the following criteria: permeability, selectivity, chemical stability or thermal sensitivity and chlorine (Bouchard et al., 2000) .Several tests conducted in laboratories of pilot pre-industrial or industrial even have mounted the technical oxygenation followed by filtration can be considered as an attractive and effective alternative to the reduction in turbidity of mineral or organic origin. The extended aeration of water can promote the hydrolysis reactions of metals (iron, etc.); and thus reduce their solubility in water to promote better precipitation of these metals (Bourgeois et al., 2004; Ferguson et al., 1995). Aeration may also lead to the flotation of particles, in particular iron, by coupling bubble particles, which can further concentrate the particles in the form of larger flocs (GRAEME and Jameson, 1999).

The objectives of this study are:

1. Carry out preliminary tests on a pilot station iron removal of groundwater
2. Evaluate subsequently the possibility of removing iron by using a natural or artificial oxygenation system.

PROBLEM OF WATER QUALITY OF CONSUMER

In the surface waters and the waters directly subject to the influence of surface water, turbidity raises concerns for reasons of health and aesthetic orders. In these waters, the suspended particles causing turbidity may contain toxins, host microorganisms and interfere with disinfection. In addition, the organic matter present in the water can react with disinfectants such as chlorine to form byproducts that may have adverse health effects (Sonede 1999).

For this reason, the turbidity monitoring can become a valuable indicator of the performance of drinking water distribution networks. In this context, preliminary test analyzes made by the Technical Directorate of Water Resources District Algerian waters (ADE) of the city of ILLIZI on the quality of drinking water, have revealed high levels of turbidity, unsuitable cases (30%), especially ferric iron levels and persistence of bacterial growth (ADE, 2012).

Accordingly, an excessive increase in the bleach consumption (7 to 8 mg Cl 2 / L for the mixture) is carried out to fill such high rates. This problem occurred as soon as one began operating six local water wells operated. That is why we decided, in this study, for an oxygenation treatment followed filtration, to reduce turbidity; especially of mineral origin, associated with the presence of ferric iron.

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LOCATION OF THE STUDY AREA

The city of Illizi is located in the extreme south east of Algeria. It covers an area of km² 284 618, with an estimated population of 33,767 inhabitants (ONS 2000), spread across 06 municipalities. It is bordered by three countries over a border of almost 1256 km, as follows:

- TUNISIA northeast, nearly 37.43 Km
- LIBYA east, nearly 1006 Km
- The NIGER south, nearly 213 Km

Inside the country, the province is limited by 02 city's:

- The province of TAMANRASSET west
- The province of OUARGLA north, the nearest administrative center is located about 1052 km from the capital of ILLIZI

It is divided into six towns (see Fig 1), namely:

- BORDJ OMAR DRISS
- DEB DEB
- In Amenas
- ILLIZI
- DJANET
- BORDJ EL HOES

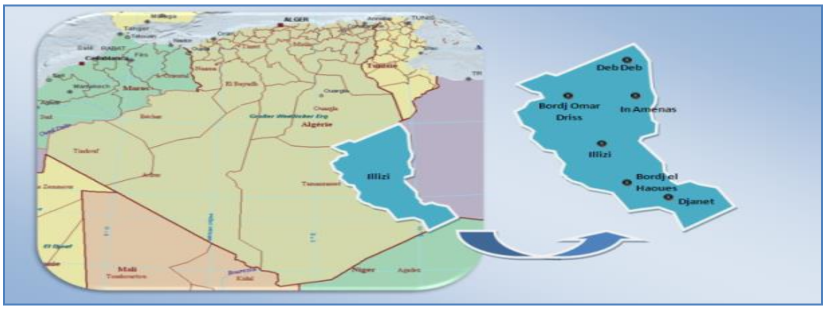

Fig 1: Location of Illizi

PHYSICOCHEMICAL QUALITY WATER-WATER ILLIZI

The results of physicochemical analyzes are presented in Tables 1, 2 and 3, clearly showing that the waters of the town of Illizi are weakly mineralized and have good mineral quality.

Table 1: Physical characteristics of water operated drilling

N° Labo	Designation	pH	Cond. µS/cm	R.S à ppm	Turbidity NTU	
					EB	ED
410	drilling Zone d'activité	6,84	580	300	25,60	22, 70
411	drilling ZHUN ILLIZI	6,97	580	340	5,70	2,90
412	drilling ZHUN 101	6,64	790	480	25	21,7
413	Forage TAKABALT	6,88	670	360	2	1, 3
415	drilling INKORS 10	6,47	600	350	32	28,9
416	drilling Siège D'POIMIA	6,65	690	420	41	38,7

Table 2: Chemical characteristics of water operated drilling

N° Labo	Designation	Ca ppm	Mg ppm	Na ppm	K ppm	Cl ppm	SO_4 ppm	CO_3 ppm	HCO_3 ppm
410	drilling Zone d'activité	46,7	15,7	42,5	3,6	58	105	0	112,35
411	drilling ZHUN ILLIZI	48,8	18,2	44,7	2,6	70	88	0	122
412	drilling ZHUN 101	80,6	20,3	50,8	3,7	76	165	0	127
413	drilling TAKABALT	60,1	17	56,3	3,6	52	133	0	153
415	drilling INKORS 10	52,2	17,5	45,6	2,6	70	120	0	85
416	drilling Siège D'POIMIA	67,9	20,4	44,1	2,8	75	146	0	101
Potable Water Standards of Algeria 6360		200	150	200	20	500	400	-	-

Table 3: Adverse and toxic elements

N° Labo	Designation	Fer (ppm)	Manganese (ppm)
410	drilling Zone d'activité	2,21	0,166
411	drilling ZHUN ILLIZI	2,598	0, 049
412	drilling ZHUN 101	2,85	0,22
413	Forage TAKABALT	1,87	0,13
414	drilling IRRIGA	3,43	0,21
415	drilling INKORS 10	2,60	0,18
416	drilling e Siège D'POIMIA	4,408	0,254
Potable Water Standards of Algeria 6360		0,3	0,5

Analyses of samples taken at ILLIZI, have high turbidity up to 41 NTU; due to the oxidation of ferric iron and iron which forms a precipitate of a rust color. Concerning other quality parameters, we can see lower conductivities than 1000 S / cm, and classify the waters of drilling ILLIZI as fairly fresh water. Before starting iron removal tests, we proceeded with the identification of key quality parameters of these waters, starting with the iron analysis. Table 3 summarizes the results obtained. We can see that the levels of different water Iron exceed the WHO standard, for these regions (1.87 mg / l and 4,408mg / l).

Nuisance related to the presence of iron in the water is the color of rust; aesthetically unappealing to the consumer, which can stain laundry and sanitary taste and a "metallic" water.

MATERIALS AND METHODS

DESCRIPTION OF THE PILOT BY NATURAL OXYGENATION deferrization (TDF)

The physical model that served us test bench consists essentially of an oxygenation tower, rectangular in cross-section. The latter is provided with apertures to ensure penetration of the air to circulate the water flow through the cascades, constituting the inside of the tower. The aerated water is recovered at the bottom of the tower into a basin connected by pipe to the Decantation tank. The latter is connected in turn to the sand filter, where water is processed and stored. The entire chain operates.

In one trial chlorine as an oxidant was added to promote Decantation.

The first stage iron removal treatment, waterfalls tower (Fig.2) is based on oxidation of divalent iron by oxygen in the air. We know that compounds of iron, lying substantially in the groundwater as ferrous Fe bicarbonate $(HCO_3)_2$.

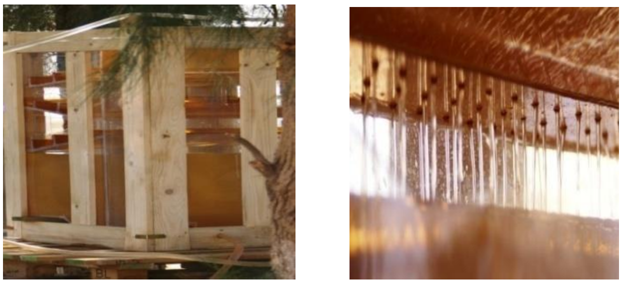

Fig 2: oxygenation Tour

In the presence of oxygen the ferrous Fe bicarbonate $(HCO_3)_2$, quickly oxidized to ferric hydroxide $Fe(OH)_3$ is insoluble in water. The process is as follows:

$$Fe(HCO_3)_2 + \text{Décarbonations à l'air} \longrightarrow Fe(OH)_3 + 2CO_2$$
$$4Fe(OH)_2 + O_2 + 2H_2O \longrightarrow 4Fe(OH)_3$$
$$4Fe(OH)_2 + O_2 + 2H_2O \longrightarrow 4Fe(OH)_3 + 8CO_2$$

This hydroxide is insoluble in the absence of organic matter, and aeration helping, a red precipitate $Fe(OH)_3$. This precipitate is removed by decantation (fig.3) and filtration.

The Decantation process is the deposition of large iron flocs resulting in a decrease in turbidity and the iron content.

Fig 3: Decantation Basin

Filtration is the substance retaining mechanism, suspended in the biofilm formed on top of the coarse sand filter (fig. 04).

Fig 4: filtration basin

Fig 5: iron removal station by natural oxygenation (TDF)

TECHNICAL ANALYSIS:

The various parameters used to assess the effectiveness of the system, were measured (RODIER, 1984):
- The turbidity measured by a turbid meter whose operating principle is based on the Tyndall effect;
- The ferrous iron and ferric by the colorimetric method Phenanthroline by means of a atomic absorption spectrophotometer;

RESULTS ANALYSIS:

Chemical analyzes were conducted on several samples:
- Sampling No. 01: water
- Sampling No. 02: after oxidation
- Sampling N°. 03: after Decantation
- Sampling N°. 04: after filtration

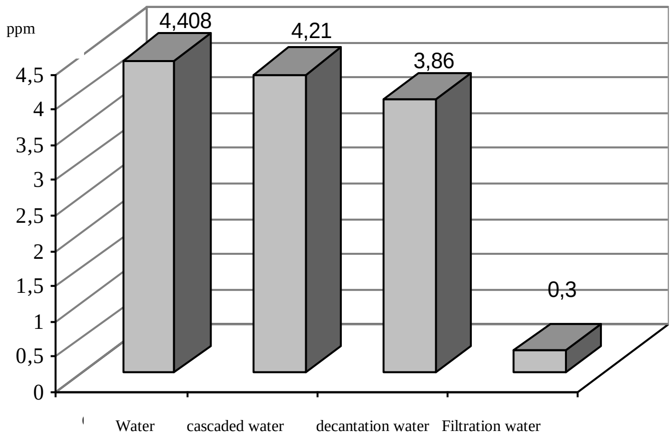

Fig 6: Iron Test Results natural oxygenation (TDF)

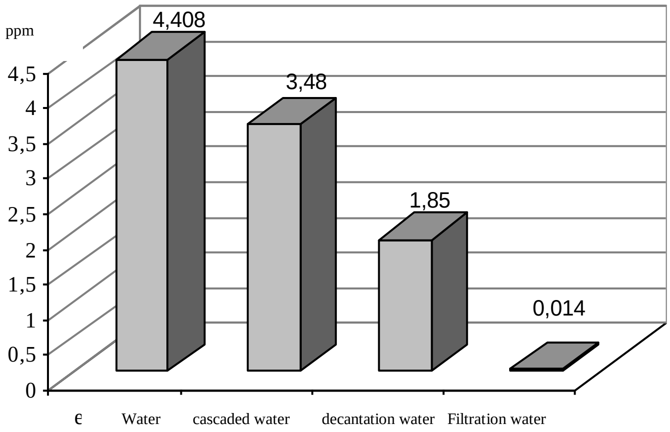

Fig 7: Iron Test Results natural oxygenation (TDF) with the oxidizing chlorine'

The study of the evolution of the total iron content in the natural oxygenation of water boreholes, shows the decrease of the total iron concentration. Indeed, the raw water initially contains 4,408 mg of iron per liter, and we see that at the end of the natural oxygenation, we arrived at a rate of 0.014 ppm.

DESCRIPTION OF PILOT DEFERRIZATION BY ARTIFICIAL OXYGENATION (ADF).

The pilot plant is shown schematically ; It has three main parts:

- Basin of oxygenation;
- Decantation basin;
- Sand filter;

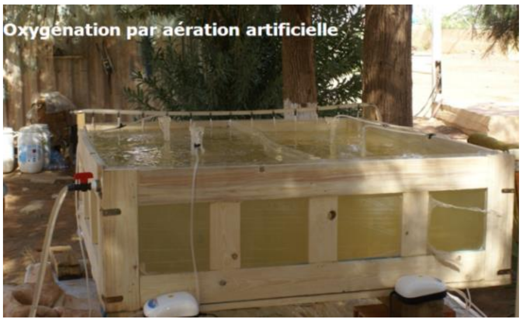

Fig 8: artificial oxygenation aeration basin

RESULTS ANALYSIS:

A simple water oxygenation (oxygen injection) may lead to an oxidation of ferrous iron to ferric iron, and so promote a better elimination of the total iron.

Drilling water treatment tests only by artificial oxygenation (ADF) have shown the elimination rate of total iron at around 0.039 and 0.026 ppm respectively for Déferrizations chlorine and chlorine (Fig.6 and 7)

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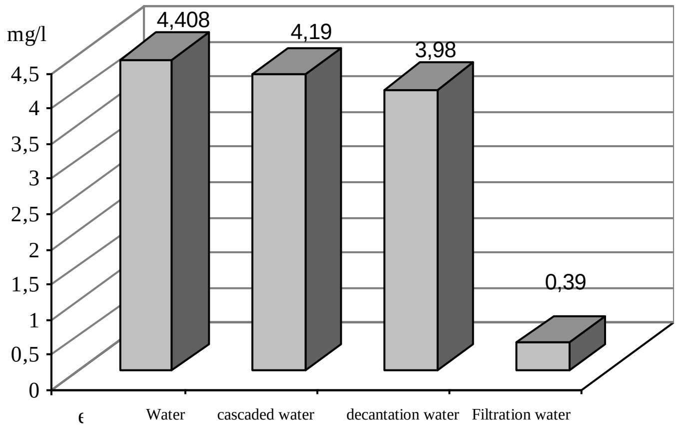

Fig 6: Iron assay results by artificial oxygenation (ADF)

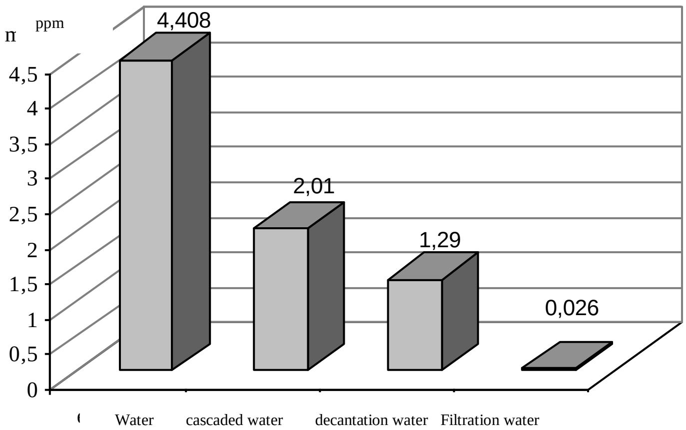

Fig7: Iron Test Results by artificial oxygenation (ADF) with the oxidizing chlorine'

DISCUSSION OF EXPERIMENTAL RESULTS

Several studies have shown that it is possible to limit the turbidity at low values by simple filtration of the water, without ventilation, when operations are carried out competently (Atherthon and Goss, 1981; Morand And Young, 1983). The process of removing turbidity is limited; especially for the case of minerals, such as iron and manganese. Since the iron is suspended in water, we had the idea to make aeration of the water to increase the iron suspension and then removing the floc formed by filtration. For this, we used two treatment processes were necessary:

- Water iron removal by natural oxygenation station (TDF)

The water treated by the pilot plant for iron removal cascade tower exhibit iron content of 0.3 ppm, just outside standards

- Water iron removal of artificial oxygenation station (ADF)

The waters treated with the experimental station of iron removal by oxygenation basin have iron contents of 0.39 ppm, slightly above the allowed limit is 0.3 ppm.

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CONCLUSION

We proposed in this work, to undertake drinking water treatment testing of a pilot station iron removal by natural oxygenation (TDF) and artificial oxygenation (ADF) water drilling operated before distribution.

The results of analyzes of water taken from different processing systems, for the proposition that the first variant: (Removal of iron by natural oxygenation (TDF) composed works: oxygenation Tour by waterfall - Decantation Basin - Basin filtration) with an addition of a strong oxidizing agent (chlorine) can completely eliminate this element (Iron) harmless to health, but unpleasant to the senses (taste and color). Indeed under the action of the air and of another strong oxidizing agent (chlorine), ferrous iron (Fe^{2+}) quickly proceed to the ferric state (Fe^{3+}) and then precipitated as iron hydroxide ($Fe(OH)_3$). This precipitate is separated from the water by decanting followed by sand filtration. The best results were obtained when natural oxygenation (TDF) with the use of a weak oxidant, such as chlorine which provides a folding 0.014 ppm. Indeed, these very satisfying results allow us to recommend the integration of natural oxygenation treatment system as operated drilling water before use, and then make a chlorination mixing waters. This cascade treatment was performed in the laboratory to achieve better returns.

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