

Quality Assessment of Afrotan Tannery Drinking Water Wells

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ABSTRACT - Afrotan tannery was established in 1983, in Albageer Industrial Area- Algazeera State - Sudan. It tans about 20000 skins per day. It uses different harmful amounts of chemicals in tanning processes and it discharges these harmful effluents in land near three drinking water wells. The objective of this study is to assess the quality of these wells and to investigate the contamination of the tannery effluents in the drinking water. Three liters of the tannery tap water was collected from a water reservoir which is fed by the above three wells. 24 parameters of Sudanese Standard Specifications for drinking waters and all the tannery effluents which are expected to contaminate the drinking water wells were measured. The results showed that there is no contamination of tannery effluents to the tannery drinking water wells, and all measured parameters were within the permissible levels of Sudanese Standard Specifications for drinking water. The study recommended periodic conduction of such studies in the future and to take the samples directly from each well to investigate any contamination.

Keywords: Afrotan Tannery, drinking water parameters, Tannery effluents.

المستخلص - انشئت مدبغة افروتان عام 1983 بمنطقة الباقير بولاية الجزيرة - السودان. المدبغة تدبغ في اليوم 20000 جلد. المدبغة تستخدم كميات مختلفة من المواد الكيميائية الخطرة في عمليات الدباغة وتطرح كميات كبيرة من هذه الكيماويات مع المياه العادمة في الارض وبالقرب من ابار مياه الشرب الثلاثة التابعة لها. الغرض من الدراسة هو تقييم جودة مياه ابار الشرب لهذه المدبغة و التحقق من تلوثها بمياه الدباغة العادمة. اخذت 3 لتر من ماء الصنبور من صهريج مياه المدبغة الذي يغذى من الابار الثلاثة المذكورة اعلاه . تم قياس 24 عنصر من مواصفات مياه الشرب السودانية وكل الملوثات الموجودة بمياه الدباغة العادمة المتوقعة ان تلوث مياه ابار الشرب. اوضحت النتائج عدم وجود تلوث بمياه الدباغة العادمة وان المياه مطابقة لمواصفات مياه الشرب السودانية. اوصت الدراسة باجراء اختبارات دورية لمياه الشرب بالمدبغة وان يتم اخذ العينات من الابار مباشرة للتحقق من التلوث.

INTRODUCTION

Water is the major chemical component and universal solvent of living system. Almost three fourths of the earth's surface is covered by water [1]. The sources' of drinking water is from surface and ground water. Ground water can be classified into three types, according to the layer which it is stored [2]. Ground water: The water that collected above the first stable impervious layer of rock it can move freely, and its surface is known as the

ground water surface. Artesian water is stored in water-containing layer sand which confined between two impervious layers. If the water rises but does not reach the ground surface it is termed sub- artesian water. It is often thought that the chemical composition is the only factor involved. However, other conditions, such as biological, physical, and radiological factors should be considered when mentioning water quality [3]. Chemical characteristics of water are measured by using the following parameters; Acidity,

alkalinity and pH. Acidity is caused by CO₂, mineral acids and salts from strong acids. Alkalinity is due to carbonates, bicarbonates and hydroxides. It is the capacity to neutralize acid. PH value denotes the nature and intensity of water towards acidity or alkalinity. Physical characteristics of water are measured by using the following parameters; Color; is influenced by natural (e.g. humic acid) and anthropogenic sources. Taste and odor are often caused by decomposition of organic compounds yielding organic acids, sulfides, etc. Turbidity is caused by suspended and fine insoluble particles and colloidal impurities like clay, silt, algae and plankton. Conductivity is easily determinable parameter presents a good measure for the total ions present in the water. Total dissolved solids (TDS) are defined as the concentration of all dissolved minerals in the water. Temperature and pH are basic parameters, important for all chemical and biological processes^[4].

To be consumable, water should be uncontaminated and hence free from germs causing water borne diseases, free from toxic substances, and free from excessive amounts of mineral and organic matters. To be potable, water should be significantly free from color, turbidity, bad taste and odor and should be stored at moderate temperature during summer and winter^[5]. Domestic and industrial effluents may join any water source and completely change water characteristics. The types of manufacturing and processing industries of importance for drinking-water contamination include chemical, metal, textile dyeing, tannery, paper and pulp, electroplating and printed circuit board manufacturing^[6].

Pure water is not easily available to all. The water may be contaminated by natural sources or by industrial effluents and leather tanning is one industrial effluents Tanning is a leader industry produces high amounts of waste water (effluents)^[7], as shown in Table I.

Tannery wastewater (Tannery effluents):

Tannery wastewaters are highly complex and are characterized by high contents of organic load, TDS, TSS, sulphate, nitrate, nitrite, ammonia, sulfides, chromium, calcium, aluminum, sodium and magnesium.

Table 1: The Compositions of Tannery Waste Water (Effluents)^[8].

Process	Pollutants
Soaking	BOD, COD, TDS, TSS and organic loads.
Unhairing	BOD, COD, TDS, TSS, sulfide, sulfate and organic loads
Liming	BOD, COD, TSS, calcium salt and organic loads.
Deliming	TDS, ammonium salts and total nitrogen.
Pickling	TDS.
Tanning	Chromium.
Retanning	Chromium, oils, dyes.

There are many chemicals that may occur in drinking-water; however, only a few are of immediate health concern in any given circumstance. The priority given to both monitoring and remedial action for chemical contaminants in drinking-water should be managed to ensure that scarce resources are not unnecessarily directed towards those of little or no health concern.

Water resource management is an integral aspect of the preventive management of drinking water quality. Prevention of microbial and chemical contamination of source water is the first barrier against drinking-water contamination of public health concern^[9].

Study area:

Afrotan Tannery Company was established in 1983. It is located in Albageer Industrial Area in Algazeera State in Sudan. It tans about 20000 of hides and skins per day. It consumes about 14000 m³/day of water for tanning processes and it drains high amount of tannery effluents in the land near wells of drinking water, these effluents are characterized by high contents of organic, inorganic and nitrogenous compounds, chromium, sulfides, suspending solids and dissolved solids. The objective of this study is to investigate the contamination of tannery effluents in the tannery drinking water wells.

MATERIALS AND METHODS:

Three liters of the tannery tap water were collected from a water reservoir which is fed by the three wells. 24 parameters of Sudanese Standard Specifications for drinking waters and all the tannery effluents parameters which are expected to

contaminate the drinking water wells were measured. Analysis was carried out in Khartoum State Water Corporation in Central Lab and in Constructional & Environmental Labs Center according to reference of Standards Methods for the Examination of Water and Waste Water, Edition 20, (1998) ^[10].

Water Quality measurement parameters:

The investigations were carried out in this study include the following:

1. Appearance (estimation).
2. Odor (estimation).
3. Color (estimation).
4. pH direct reading color comparison method (relative method).
5. *Suspended solids*: Direct measurement by using (HACH) 2000 DR spectrophotometer with wavelength (λ) 810 nm. Result reported in mg/l suspended solids.
6. Electric conductivity: Direct reading by using conductivity meter. Result reported in $\mu\text{s}/\text{cm}$.
7. Temperature direct reading by thermometer.
8. *Turbidity (nephelometric method)*: This method depend on a comparison of the intensity of light scattered by the sample under defined condition with the intensity of light scattered by standard reference suspension under the same condition . Procedure: Direct reading by using (HACH) 2100 Turbidity meter. Result reported in (NTU).
9. *Hardness (total)*: Dissolved minerals cause hardness in water primarily divalent cations Calcium and Magnesium ions usually are the only ions present in significant amount therefore hardness generally is considered to be a measure of the Calcium and Magnesium content of water.
10. *Procedure*: The pH of the sample was adjusted to 10 with ammonium chloride/hydroxide solutions, addition of Eriochrome black T indicator followed by titration Vs (EDTA disodium salt). Result recorded as mg/l total hardness calculated as calcium carbonate.
11. *Calcium*: Calcium hardness determined after removing magnesium interference by adjusting the pH of the sample to 12 with sodium hydroxide, then the amount of calcium was calculated. The result reported as mg/l calcium.
12. *Magnesium*: Magnesium determined by using mathematical method by subtracting the calcium hardness from total hardness the remained amount

contributed to the magnesium. The result reported in mg/l magnesium. The method for total hardness, calcium and magnesium taken from (quantitative inorganic chemistry).

13. *Total alkalinity*: Alkalinity of water is the capacity of water to neutralize acids, it is expressed as phenolphthalein and total, both types are determined with direct titration Vs standard sulfuric acid solution. Result reported in mg/l calcium carbonate.

14. *Chloride*: Sample titrated Vs standard silver nitrate solution in the presence of potassium chromate as indicator. Result reported in mg/l chloride.

15. *Nitrate*: Cadmium metal reduce nitrates present in the sample to nitrite which in acidic medium react with sulfanilic acid to form an intermediate diazonium salt, this salt couples with gentistic acid to form an amber colored product the intensity of color directly proportion to the amount of nitrate wavelength (λ) is 500 nm. Instrument: (HACH) 2000 DR spectrophotometer. Result reported in mg/l nitrate.

16. *Nitrite*: Nitrite in the sample reacts with sulfuric acid to form an intermediate diazonium salt couples with chromo tropic acid to form pink colored the intensity of color in proportional to the amount of nitrite in the sample. Wavelength (λ) is 507 nm. Instrument: (HACH) 2000 DR spectrophotometer. Result reported in mg/l nitrite.

17. *Sulfate*: Sulfate in sample react with barium chloride to form a precipitate of barium sulfate the amount of turbidity formed is directly in proportion to the amount of sulfate. Wavelength (λ) 450 nm. Instrument: (HACH) 2000 DR spectrophotometer. Result reported in mg/l sulfate.

18. *Fluoride*: By using Spans method: This method involve the reaction of fluoride with a red zirconium – dye solution the fluoride react with part of the zirconium to form a colorless complex thus bleaching the red color in amount proportional to the concentration of fluoride in the sample. Wave length (λ) 580 nm. Instrument: (HACH) 2000 DR spectrophotometer. Result reported in mg/l fluoride.

19. *Iron total*: ferover method: Ferover reagent convert all soluble & most insoluble forms of iron in the sample to soluble ferrous iron which react with 1,10 phenanthroline in the reagent to form an

orange color the intensity of color is proportional to the amount of iron in the sample.

20. *Wavelength (λ) 510 nm. Instrument:* (HACH) 2000 DR spectrophotometer. Result reported in mg/l total iron.

21. *Total dissolved solids (TDS):* Direct reading by using conductivity (TDS) meter. Result reported in mg/l (TDS).

22. *Chromium and Aluminum* were measured by Shimadzu Atomic Absorption Spectroscopy (AA – 6300 (P/N 206 - 51800)) Shimadzu – Tokyo – Japan.

RESULTS AND DISCUSSION

The color of water should be clear and bright, but natural organic matter may occasionally impart a slight yellowish tint to surface supplies ^[10]. Regarding the tannery effluents contain fine organic matter, the result from Table II showed that the color of the sample is acceptable and that mean no contamination by organic matters.

Table II: Results of Physical Parameters in the Tannery Drinking Water

Parameters	Value	Sudanese STDs	Unit
Appearance	Clear	Acceptable	
Turbidity	0.72	5 NTU	5 NTU
Color	No color	15 TCU	15 TCU
Odor	Nil	Acceptable	
pH	8.1	6.5 – 8.5	
Temperature	24.3	Acceptable	C
E. Conductivity	517.8	2500	$\mu\text{S}/\text{cm}$ at 20°C
T.D.S	310.7	1000	mg/l
T. Alkalinity	198	200	mg/l
pH. pH. Alkalinity	Nil		mg/l
T. Hardness	0.19	200	mg/l

PH (hydrogen ion) is a measure of the acidity or alkalinity of water ^[11]. Regarding the tannery effluents contain acids and bases, the result from Table II showed that the pH of the sample within the permissible level, so no contamination.

Turbidity is due to fine particles suspended in the water, causing cloudiness ^[4]. Regarding the tannery effluents contains fine particles suspended, the result from Table II showed that the turbidity

of the sample within the permissible level, so no contamination.

Alkalinity is normally due to bicarbonate salts of calcium and magnesium, but very occasionally sodium bicarbonate may contribute ^[1]. Regarding the tannery effluents contain salts, the result from Table II showed that the alkalinity in the sample within the permissible level, so no contamination. Hardness is due to calcium and magnesium salts (bicarbonate, chloride, sulphate and nitrate) dissolved in the water ^[12]. Regarding the tannery effluents contain calcium and magnesium salts, the result from Table II showed that the hardness in the sample within the permissible level, so no contamination.

The conductivity is a measurement of the mineral salts dissolved in the water ^[10]. Regarding the tannery effluents contain minerals and salts, the result from table II showed that the conductivity of the sample within the permissible level, that means no contamination.

Odor and taste are the measure of the aesthetic quality of drinking water. Unusual odors or tastes may indicate a problem which needs investigating ^[10]. Regarding taste and odors occur in tannery effluents; the result from Table II showed that there are no taste and odor in the samples and that means no contamination.

Anions in the tannery drinking water:

Aluminum in some water sources occurs naturally ^[15]. Regarding the tannery effluents contain aluminum, the result from Figure1 showed that the aluminum in the sample within the permissible level.

Chromium is rarely found in drinking water ^[14]. The result from Figure1 showed that the measurement of Chromium by the use of atomic absorption spectroscopy showed that chromium is below detection limit i.e. below 0.01ppm and the Sudanese Standard Specifications for drinking water allowed limit is 0.04ppm. Manganese occurs naturally in many waters ^[17]. But tannery effluents not contain manganese, the result from Figure 1 showed that the manganese of the sample within the permissible level. Iron is a commonly occurring and natural element in most water sources ^[16]. But tannery effluents not contain iron, the result from Figure 1 showed that the iron of the sample within the permissible level.

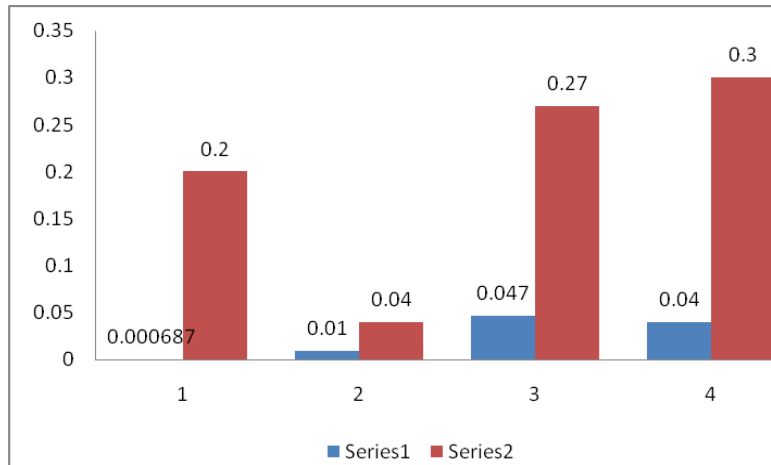


Figure 1. Al (1), Cr (2), Mn (3) and Fe (4) mg/l in the tannery drinking water (series 1) and the permissible level of Sudanese Standard Specifications of above anions for drinking water (series 2).

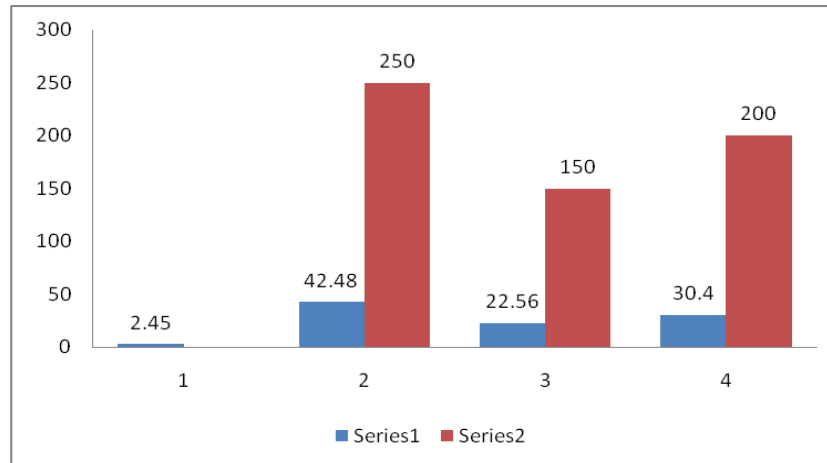


Figure 2: K (1), Na (2), Mg (3) and Ca (4) mg/l in the tannery drinking water (series 1) and the permissible level of Sudanese Standard Specifications of above anions for drinking water (series 2).

Potassium Occurs naturally in water after passing through certain mineral deposits and rock strata [10]. It not occurs in tannery effluents and the result from Figure 2 showed that the potassium in the sample within the permissible level.

Sodium is a component of common salt and occurs naturally in water after contact with particular mineral deposits and rock strata [13]. Regarding the tannery effluents contain sodium, the result from Figure 2 showed that the sodium in the sample within the permissible level, so no contamination.

Magnesium Occurs naturally in water after passage through mineral deposits and rock strata.

Magnesium contributes to the total hardness of water [12], and the tannery effluents not contain magnesium, the result from Figure 2 showed that the magnesium in the sample within the permissible level, so no contamination.

Calcium Occurs naturally in water after passage through mineral deposits and rock strata. Calcium contributes to the total hardness of water [12]. Regarding the tannery effluents contain calcium, the result from Figure 2 showed that the calcium in the sample within the permissible level, so no contamination.

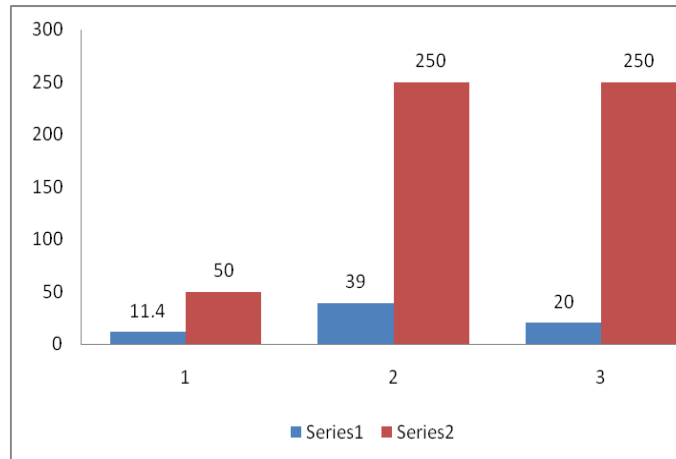


Figure 3: NO₃ (1), SO₄ (2) and Cl (3) mg/l in the tannery drinking water (series 1) and the permissible level of Sudanese Standard Specifications of above cations for drinking water (series 2).

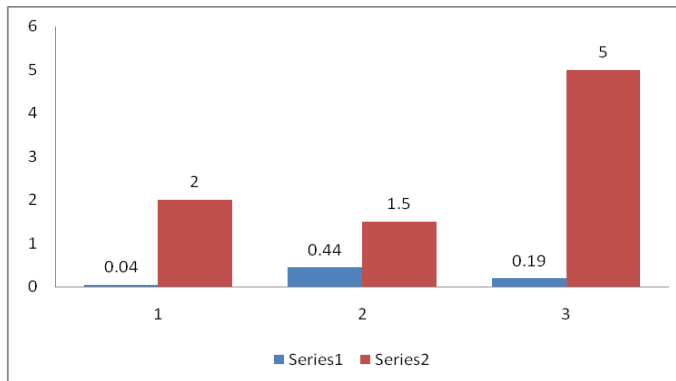


Figure 4: NO₂ (1), F (2) and PO₄ (3) mg/l in the tannery drinking water (series 1) and the permissible level of Sudanese Standard Specifications for drinking water (series 2).

Cations in the tannery drinking water:

Nitrate occurs naturally at low level in many sources of water [18]. Regarding the tannery effluents contain nitrate, the result from Figure 3 showed that the nitrate in the sample are within the permissible level, that mains no contamination.

Sulphate occurs naturally in many source waters after contact with particular mineral deposits and rock strata [21]. Regarding the tannery effluents contain sulphate, the result from Figure 3 showed that the sulphate in the sample within the permissible level, so no contamination. Chloride occurs naturally in source water and is a component of common salt [19]. Regarding the tannery effluents contain chloride, the result from Figure 3 showed that chloride in the sample within the permissible level. Nitrite occurs naturally at low level in many sources of water [18]. Regarding the tannery effluents contain nitrite, the result from Figure 4 showed that the nitrite in the sample is

within the permissible level, that main no contamination.

Fluoride occurs naturally in water at varying concentrations [20]. But tannery effluents not contain fluoride, the result from Figure 4 showed that the fluoride of the sample within the permissible level. Phosphate occurs naturally in water [10]. The result from Figure 4 showed that it not occurs in the sample.

CONCLUSION

This paper on the quality assessment of Afrotan Tannery drinking water wells. All the measured parameters of drinking water were found to be within the permissible level of Sudanese Standard Specifications for drinking water and there is no contamination of tannery effluents to the tannery wells of drinking water. The study recommended periodic conduction of such studies in the future

and to take the samples directly from each well to investigate any contamination.

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