The Content of Some Metal Pollutants in Efeluents of Leather Tanning Industry

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ABSTRACT

This research work was conducted to determine the metal pollutants namely chromium, iron, manganese and zinc that result from the process of leather tanning industry in Khartoum. The determinations were performed in samples collected from wastewaters and tap water of Khartoum Tannery and from two locations at Soba Treatment Plant; (Soba In the inlet and Soba Out the outlet). The results were compared to the permissible levels stated by FAO and Sudanese Standard and Metrology Organization (S.S.M.O).

Analysis of Tannery wastewaters showed that: the mean concentrations of chromium, iron, manganese are higher than S.S.M.O and FAO permissible level. The mean concentrations of zinc are below the permitted level stated by S.S.M.O but slightly higher than that of FAO.

Analysis of Soba In wastewaters showed that the mean concentrations of chromium, iron and manganese were higher than S.S.M.O and FAO permissible level. Analysis of Soba Out wastewaters showed that: mean concentrations of iron, and chromium are higher than S.S.M.O. and manganese mean concentration is higher than S.S.M.O and FAO permissible level. Reduction of tannery waste pollution impacts can be achieved by applying different treatment techniques to protect the environment and human health.

Keywords: Tannery wastewater

INTRODUCTION

The trade in leather goods and leather products is particularly important for a number of developing countries. It is an important source of both employment and foreign exchange.

Sudan enjoys vast animal resources that place the country among the richest African countries in this sector. The Sudan's animal wealth is estimated at about 121 million heads, thus it is expected to find great expansion in leather industry (Industrial-sector). Leather tanning industry is performed in many tanneries In Sudan. Tanning is a chemical process that involves the use of different chemicals including chromium which proved to be toxic to human as well as to many living species. (Barnhart 1997 and UNIDO 2005) . Lime-sulphide was used with a natural product called trona at the required concentration and pH. The solution obtained was used for dehairing. The hair was completely removed. (Gasmelseed 2001) .

The objective of this research was to study the inorganic pollutants of leather tanning industry in Khartoum Province. The impact of toxic metals like chromium, iron, zinc and manganese on the environment is more pronounced than that of organic pollutants because these metals are not biodegradable as is the case with most organic pollutants.

MATERIALS AND METHODS

Preparation of samples

Samples were collected from Khartoum Tannery wastewater and Soba Sewage Treatment Plant. The tannery wastewater is pumped from the different stages of leather tanning process into a pond. Samples were collected from this pond which is the main discharge outlets of the Tannery. Tannery wastewater then flows from the pond into a channel towards Khartoum sewage system till it reaches Soba Sewage Treatment Plant. Soba Sewage Treatment Plant consists of the following units: receiving well, pumping station, , anaerobic, facultative and maturation ponds.

Tannery wastewater Samples:

A sample of one dm^3 volume was collected from the wastewater of the last pond of the tannery. This process of sample collection was repeated every two hours over a 12 hour period a day resulting in six samples. The six collected samples were mixed thoroughly together to form one composite sample. The composite sample was preserved by acidifying with concentrated nitric acid and stored in a refrigerator for analysis. The process of collecting composite sample was repeated for a whole year five times every month giving a total of 60 composite samples.

Composite samples were collected from the first pond of STP, the anaerobic pond in the same way as mentioned in tannery samples giving a total of 60 composite samples. The sample is denoted by “Soba In”. Also 60 composite samples were collected in the same way from the

channel situated at the end of the treatment plant after the maturation pond that leads the waste to the White Nile. This sample is denoted by “Soba Out”.

Tannery tap water Samples

Samples were also collected from the Tannery tap water. Tannery tap water is used in all the stages of tanning processes. The process of collecting samples was repeated three times (every four months) over a period of one year giving a total of 9 samples. The samples were preserved for analysis.

Analytical methods

Procedure

Samples were prepared by acid digestion. Tannery wastewater and the general sewage system wastewater consist of many organic and mineral containing silicates. Nitric acid alone is inadequate for their digestion thus the combination of nitric acid and perchloric acid was chosen for the digestion (M.C.Rand *et al*. and Hoeng M. & A. M. Kersabiec 1992).100 cm^3 of acid preserved samples were transferred to a flask with the addition of 5 $cm^3$of concentrated HNO_3 acid in a fume cupboard. Flask content was evaporated to 15-20 cm^3 and cooled. 10 cm^3 of each conc. HNO_3 and $HClO_4$ were added with cooling between additions of the acids. Evaporation was carried gently on a hot plate until dense white fumes of $HClO_4$ just appear.

The flask content was cooled and diluted to 50 cm^3 with distilled water, and boiled to expel any chlorine or oxide of nitrogen (M.C. *et al.*). The solution was filtered through prewashed 0.45-μm-pore-diam membrane filter. The filtrate was transferred to a 100 cm^3 volumetric flask, rinsing were added and the solution was diluted up to the mark. After thorough mixing, portion of this solution was analyzed by flame AAS (Shimadzo AA-6800) by the standard addition method for the determination of chromium, iron, zinc and manganese (Agett, J.& A. C. Aspel1976 , ASTM Standard 1987).In standard addition known quantities of standard were added to identical aliquots of the sample, thereby allowing any interferent present in the sample to affect the standard similarly (Douglas A. *et al* 1999 and Willard *et al*).

Graphite furnace atomic absorption spectroscopy was applied in the determination of chromium, iron, zinc and manganese concentrations in Tannery tap water (Khan, H.L).

Arsenic in Tannery, Soba In, Soba Out wastewaters samples after acid digestion and filtration was also determined by graphite furnace atomic absorption spectroscopy. The investigation showed that arsenic is not detected in all of the samples (.Fifield and Kealey).

RESULTS

The Concentrations of pollutants of Tannery, Soba In, Soba Out wastewaters and Tannery tap water were obtained from the calibration curves. The concentrations of pollutants are listed in Table (1) to Table (5).

Table (1) Mean Concentrations of pollutants in ppb in Tannery tap water

Sample number	Chromium	Iron	Zinc	Manganese
1	0.03	0.16	0.04	0.40
2	0.04	0.14	0.06	0.20
3	0.06	0.17	0.05	0.35
Mean ±SD	0.043±0.003	0.157±0.002	0.05±0.01	0.317±0.104

Table (2) Mean concentration values (mg dm^{-3}) of chromium

Sample No. Months	Tannery	Soba In	Soba Out
April	105.57	2.10	1.62
May	116.53	1.64	0.21
June	119.53	3.93	0.56
July	121.62	2.33	0.41
August	121.62	2.60	0.70
September	115.87	5.10	1.64
October	130.01	4.37	1.50
November	97.76	2.60	1.31
December	99.55	2.57	1.50
January	88.13	2.80	1.12
February	99.83	1.82	0.99
March	114.56	1.79	0.84
Mean ±SD	111.00 ± 12.50	2.81± 1.10	1.05± 0.49

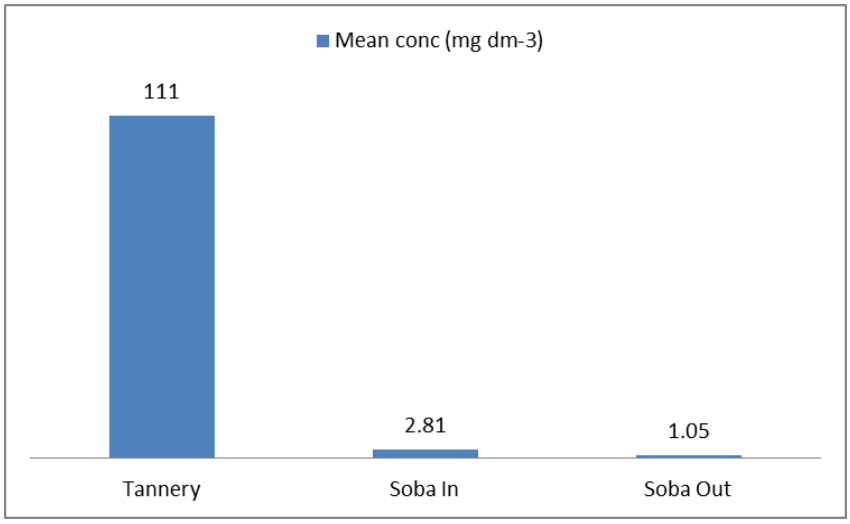


Figure (1) Mean concentration values (mg dm^{-3}) of chromium

Table (3) Mean concentration values (mg dm^{-3}) of iron

Sample No. Months	Tannery	Soba In	Soba Out
April	11.34	5.11	2.18
May	7.17	5.24	2.90
June	8.93	6.63	0.54
July	12.25	7.61	0.32
August	11.75	7.59	4.37
September	9.85	5.19	1.05
October	11.24	4.19	2.88
November	11.63	4.42	2.96
December	11.23	7.99	3.36
January	9.79	6.55	3.10
February	8.85	6.78	2.18
March	8.44	4.18	2.31
Mean ±SD	10.18±1.62	6.04±1.38	2.51±1.01

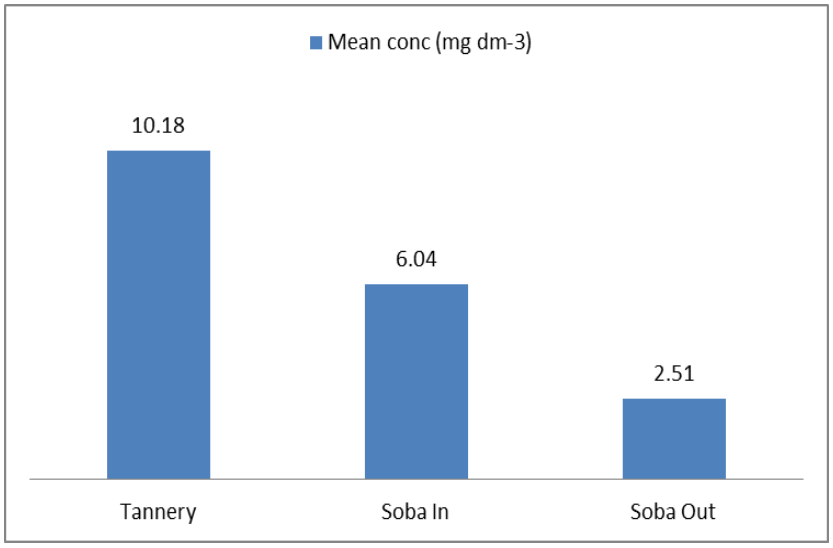


Figure (2) Mean concentration values (mg dm^{-3}) of iron

Table (4) Mean concentration values (mg dm^{-3}) of manganese

Sample No. Months	Tannery	Soba In	Soba Out
April	1.09	0.88	0.54
May	1.10	0.90	0.49
June	1.11	0.62	0.48
July	1.10	0.79	0.43
August	1.10	0.89	0.49
September	1.12	0.62	0.36
October	1.63	0.87	0.32
November	1.59	0.95	0.54
December	1.73	0.88	0.53
January	1.78	0.92	0.53
February	0.98	0.55	0.50
March	1.12	0.89	0.53
Mean ±SD	1.29± 0.29	0.81±0.17	0.48±0.01

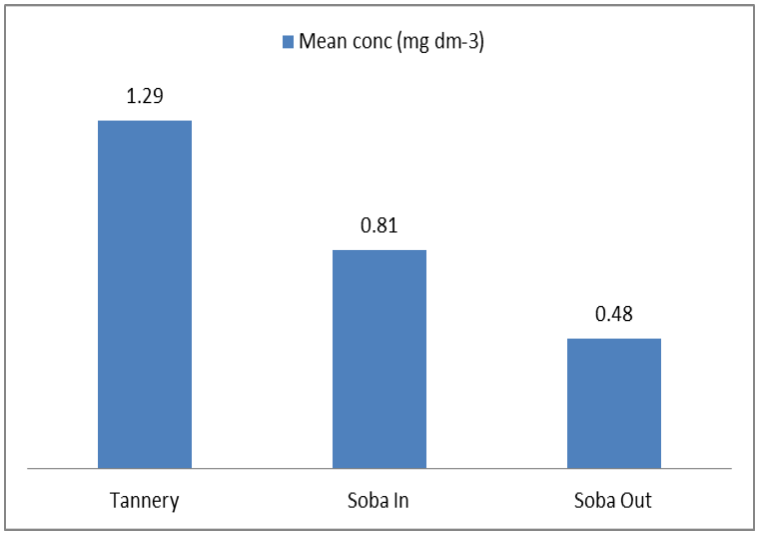


Figure (3) Mean concentration values (mg dm^{-3}) of manganese

Sample No. Months	Tannery	Soba In	Soba Out
April	1.78	1.04	0.26
May	1.99	1.04	0.71
June	1.34	1.06	0.50
July	1.56	0.93	0.51

August	2.63	1.18	0.57
September	2.09	1.59	0.66
October	1.56	0.74	0.44
November	1.52	1.00	0.71
December	3.55	1.27	0.63
January	1.41	0.75	0.39
February	2.69	0.93	0.53
March	3.28	0.97	0.32
Mean ±SD	2.12±0.75	1.05±0.23	0.52±0.15

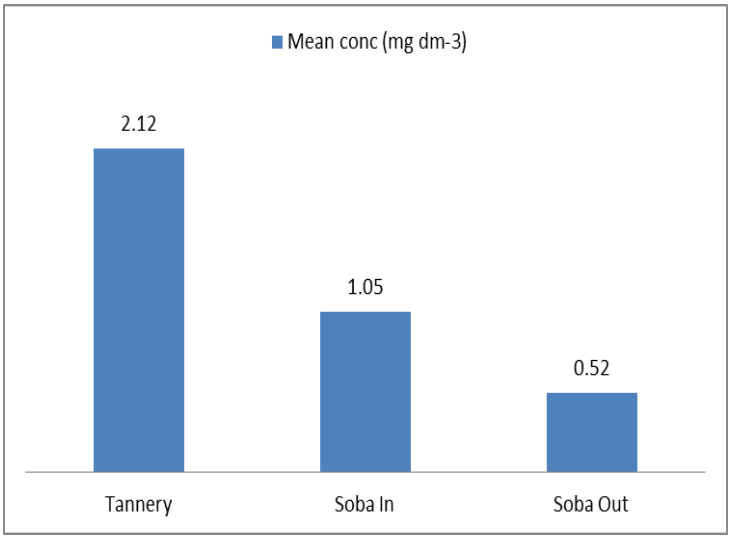


Figure (4) Mean concentration values (mg dm^{-3}) of zinc

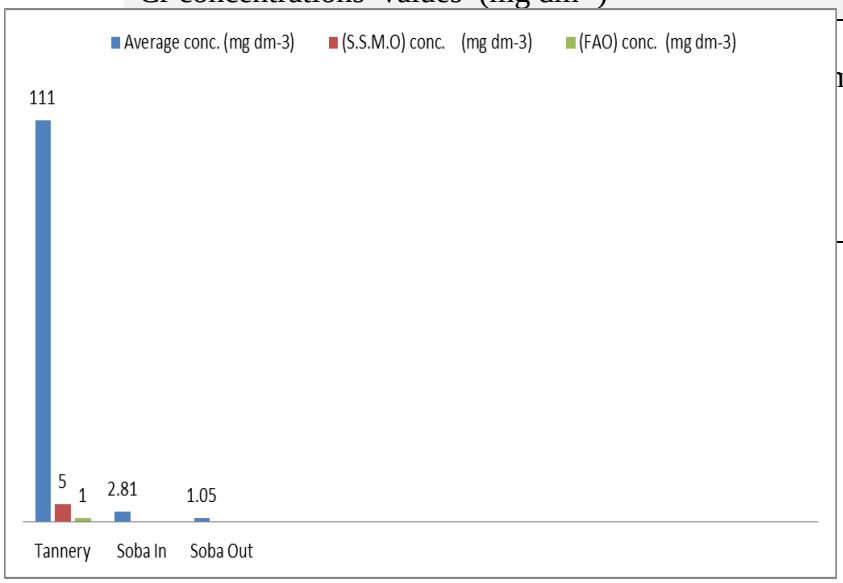
The result of analysis using furnace AAS technique shows that arsenic is not detected in Tannery, Soba In and Soba Out wastewaters.

Comparison of Concentration Levels of Metal Pollutants with the Permissible levels:

The results of the concentration levels of metal pollutants are compared with the permissible concentration levels stated by the authorized bodies namely:
1- (S.S.M.O.) standard, Sudanese Standard and Metrology organization.
2- FAO, the United Nations Food and Agriculture Organization standards.

Table (6) Comparison of Cr concentrations values (mg dm^{-3}) in tannery, Soba In and Soba Out wastewaters with the permissible levels of concentrations

Cr concentrations values (mg dm^{-3})	conc. n^{-3})



Soba In and Figure (5) Comparison of Cr average concentrations values (mg dm^{-3}) in tannery, Soba Out wastewaters with the permissible levels of concentrations

Table (7) Comparison of Fe concentrations values (mg dm^{-3}) in tannery, Soba In and Soba Out wastewaters with the permissible levels of concentrations

Fe concentrations values (mg dm^{-3})			
Location	Average conc. (mg dm^{-3})	(S.S.M.O) conc. (mg dm^{-3})	(FAO) conc. (mg dm^{-3})
Tannery	10.18	5	1
Soba In	6.04		
Soba Out	2.51		

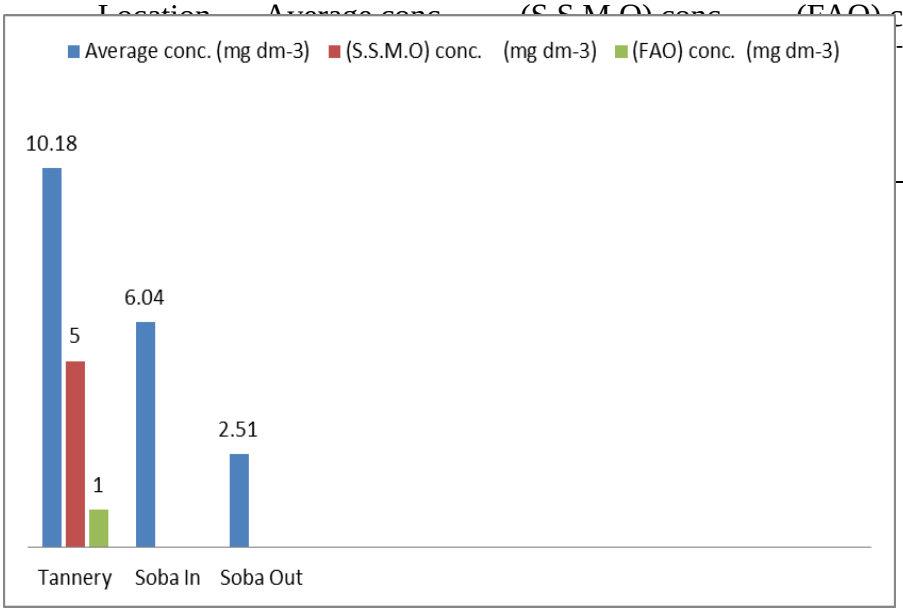
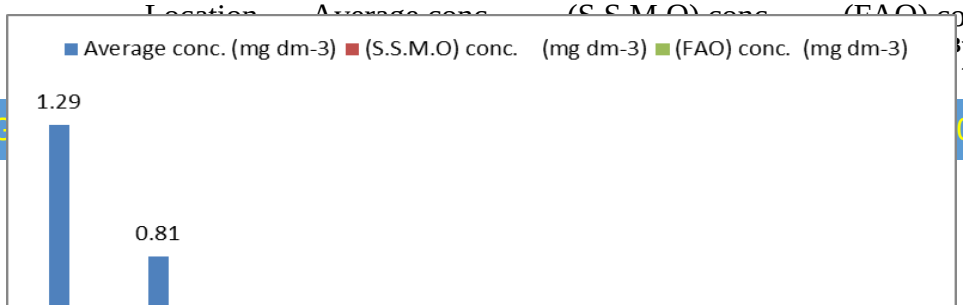


Figure (6) Comparison of Fe average concentrations values (mg dm^{-3}) in tannery, Soba In and Soba Out wastewaters with the permissible levels of concentrations

Table (8) Comparison of Mn concentrations values (mg dm^{-3}) in tannery, Soba In and Soba Out wastewaters with the permissible levels of concentrations

Mn concentrations values (mg dm^{-3})			
Location	Average conc. (mg dm^{-3})	(S.S.M.O) conc. (mg dm^{-3})	(FAO) conc. (mg dm^{-3})
Tannery	1.29	0.81	0.2



Tannery	1.29	0.1	0.2
Soba In	0.81		
Soba Out	0.48		

Figure (7) Comparison of Mn average concentrations values (mg dm^{-3}) in tannery, Soba In and Soba Out wastewaters with the permissible levels of concentrations

Table (9) Comparison of Zn concentrations values (mg dm^{-3}) in tannery, Soba In and Soba Out wastewaters with the permissible levels of concentrations

Zn concentrations values (mg dm^{-3})			
			) conc. dm^{-3})
Tannery	2.12	5	2
Soba In	1.05		
Soba Out	0.52		

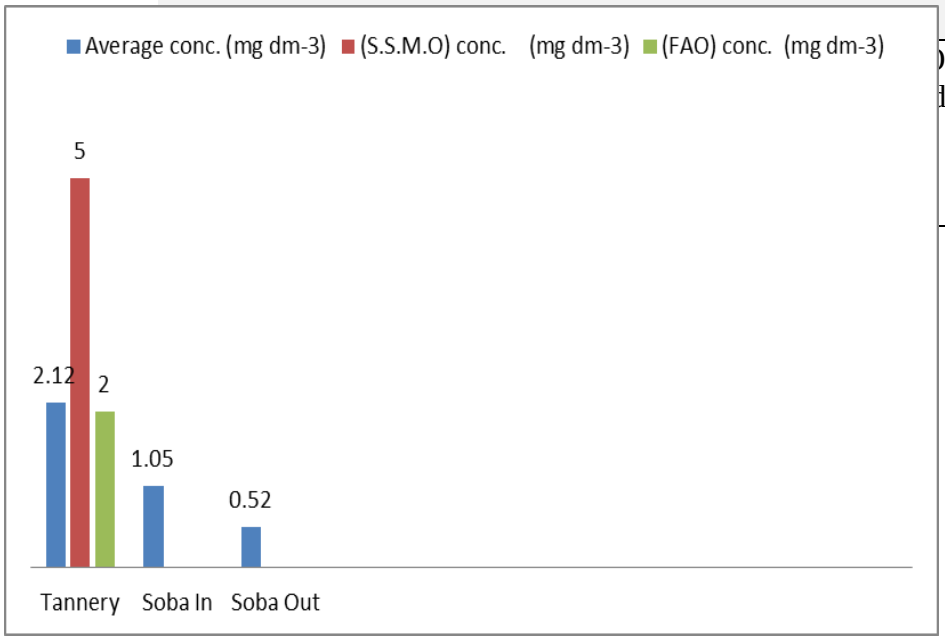


Figure (8) Comparison of Zn average concentrations values (mg dm^{-3}) in tannery, Soba In and Soba Out wastewaters with the permissible levels of concentrations

DISCUSSION

Table (1) shows that the mean concentrations of the four metal pollutants under investigation are in the range of ppb in Tannery tap water.
Table (6) shows that the values of chromium concentrations of the tannery wastewater are extremely high compared with all the permissible levels.
Chromium concentration levels in Soba In wastewater are lower than S.S.M.O permissible level but higher than that of the FAO permissible level. Also chromium concentration levels in Soba Out wastewater are higher than the S.S.M.O permissible level but higher than that of the FAO permissible level.
Table (7) also shows that the values of iron concentrations of the Tannery Soba In wastewaters are extremely high compared with the permissible levels while Soba Out wastewater concentration of iron is above the limit permissible by FAO but below the permitted levels by S.S.M.O.
Table (8) shows that the values of manganese concentrations of the tannery, Soba In and Soba Out wastewaters are extremely high compared with all the permissible levels.
Table (9) also shows that the values of zinc concentrations in Soba In and Soba Out for all the tested samples lie below the permissible levels of concentrations stated by S.S.M.O. and FAO. Tannery wastewaters concentrations of zinc are below the permissible level of concentration stated by S.S.M.O but slightly higher than that of FAO.
The real effect of Soba Treatment Plant is quite evident by the marked reduction of the concentrations as shown in the analytical results of Soba Out wastewater though the concentrations of some pollutants are still above the permissible levels as mentioned before. However the reduction of Cr, Fe, Mn and Zn concentration at the outlet of the ponds could be due to dilution or precipitation effects.

CONCLUSION

It is evident from the results obtained from this research work that the Tannery waste creates a serious environmental impact as it has a very high pollution loads containing several toxic metal pollutants Cr, Fe, Mn and Zn. Different treatment techniques have to be applied to reduce tannery waste pollution impacts so as to protect the environment and human health.

In order to avoid the negative environmental impact of chromium it is recommended to recycle it or precipitation through electrolysis.

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تعيين الملوثات غير العضوية الناتجة من صناعة الجلود بالسودان

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الخلاصة

الهدف من هذا البحث هو تعيين العناصر غير العضوية الملوثة الناتجة من صناعة الجلود بالمياه العادمة من مدبغة الخرطوم و من موقعين بمحطة سوبا لمعالجة المياه العادمة. قورنت نتائج التحاليل بمستويات التراكيز المصدق بتواجدها فى المياه العادمة من قبل الهيئات والمنظمات ذات الاختصاص المحلية و الاقليمية و العالمية. جمعت العينات للتحاليل من المواقع المذكورة اعلاه و استخدمت تقنيات مطيافية الامتصاص الذرى لتعيين المعادن كمياً. اظهرت نتيجة التحليل بان متوسط تركيز عنصر الكروم لمياه المدبغة العادمة اعلى من الحد المسموح به من هيئة المواصفات والمقاييس. متوسط تركيز عنصر الحديد أعلى من الحد المسموح به من هيئة المواصفات والمقاييس ومنظمة الامم المتحدة للأغذية والزراعة (الفاو). تركيز عنصر المنجنيز أعلى من الحد المسموح به من هيئة المواصفات والمقاييس و منظمة الفاو. أظهرت التحاليل للعينات التى أخذت من الموقع الاول بمحطة سوبا لمعالجة المياه العادمة بأن متوسط تركيز عنصر الكروم اعلى من الحد المسموح به من هيئة المواصفات والمقاييس و الفاو. تركيز عنصر الحديد(1.38±) أعلى من الحد المسموح به من الفاو. تركيز المنجنيز أعلى من الحد المسموح به من هيئة المواصفات والمقاييس ومنظمة الفاو. أظهرت التحاليل العينات التى أخذت من الموقع الثاني بمحطة سوبا لمعالجة المياه العادمة بأن تركيز عنصر الكروم أعلى من الحد المسموح به من هيئة المواصفات والمقاييس. تركيز عنصر الحديد أعلى من الحد المسموح به من منظمة الفاو. تركيز عنصر المنجنيز اعلى من الحد المسموح به من هيئة المواصفات والمقاييس و الفاو. أوضحت نتائج البحث أن صناعة الجلود لها التأثير السالب فى مجال التلوث البيئي بما تفرزه هذه الصناعة من مواد ضارة بصحة الانسان وبالبيئة تعدت الحد المسموح به. هذه الاضرار يمكن تفاديها باتباع معالجات تؤدى الى نقصان هذه الاثار السالبة وذلك بتدوير الكروم و استعمال المياه العادمة فى الري بعد التأكد من ازالة المواد الملوثة الموجودة بها.