(RESEARCH ARTICLE)

Assessment of significant metals in effluents, soil, and pond water of tanneries south of capital of Sudan state

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Abstract

In the present study, impact of tannery effluents and their subsequent on accumulation of some metals (Ca, K, Na, Mg, Cl, S, Cr, Fe, Mn, Pb, and Zn) in water and soil samples in and around South Khartoum industrial area, Khartoum-Sudan were studied. Concentration of metals in tannery effluents (SA), adjacent contaminated pond water (SB), Soil (SC), and uncontaminated water (SD) were assessed by atomic absorption photometer. The results showed high levels of Ca, K, Na, Mg, Cl, S, Cr, Fe, Mn, Pb, and Zn within the water from all sampling point (SA, SB and SC). The investigation exhibited that tanneries wastewater has high mean concentrations of Cr, Fe, Mn, and Pb in all sampling point of effluent, pond water, soil, and uncontaminated water, except Zn which is high only in soil sampling point (SC). The significant metals accumulation displayed a pattern of mean concentration as follow: Soil > Effluent >contaminated pond water > Un contaminated water. Significant metals toxicity levels within the totally different sampling points were compared with water from WHO. Mean metal concentrations in un contaminated water were among the allowable limit set by WHO except for Magnesium (Mg). The comparison indicated that soil (SC) within the neighboring industrial area accumulated metals, enhanced levels of toxic of metals such as Cr, Ni, Zn and Pb, which also demonstrated higher concentration levels in the adjacent contaminated pond water samples. increased levels of poisonous, that additionally incontestable higher concentration levels within the contaminated pond water.

Keywords: Heavy meals; Mean Concentration; Tannery effluent; Soil; Contamination

1. Introduction

Tannery industries manufacture large quantity of contaminated effluents that usually discharged to surface water bodies and spring water aquifers. The pollutants of waste matter injury the terrestrial ecological system and inflicting a prolonged term serious adverse health impact [1-3]. The problems of environmental pollution are arising hugely due to disposal of wastes [4-6]. Poisonous metals and trace metals within the effluent from process of animal skin is kind of hazards to water and soil [6,7]. The industrial growth in south of capital of Sudan has been presently redoubled up to considerably enhance economic process. The environmental contamination state of affairs within the space is turning into a lot of serious day by day. This example demands a strict treatment program for the effluents from work trade involving safe disposal. Resources area unit secured against any raised levels of the fatal metals, as reported for alternative elements of the globe [8-10].

The present study was carried out to examine a chemical analysis for the quality of effluent in tannery in several sampling points in view of the potential influence of hazard waste from tannery process and domestic effluents on near water resources and soil system.

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1.1. Area of study

Khartoum, the urban center of Sudan, settled in central Sudan at the junction of the headstream and also the headstream Rivers (Figure 1). West of river is that the Omdurman city. Capital of Sudan State occur between longitudes 31.5 to 34°E and latitudes 15 to 16°N. This analysis work was done on industrial space south of Khartoum; between the latitudes 140-24 ' N 280-33 ' E, and longitudes 150-00' N, 201- 33' E. The study area enclosed Khartoum tannery and White Nile tannery (Figure 1).

Figure 1 Map showing location of study area (Source- capital of Sudan – Wikipedia Google Maps)

2. Material and methods

2.1. Study area and sampling

Khartoum Tannery and White Nile Tannery settled at South of capital of Sudan, 20 kilometers from Centre of Khartoum the Capital of Sudan, 12 kilometers from White Nile River, 30 kilometers from Blue Nile River. Tannery wastewater from the investigate area has been collected and pretreated, the treated water is discharge into the oxidation pond and sedimentation pond. The generated sludge has been collected from the tank of sedimentation and dumped outside the study area. The key treatment technology that been used is Cyclic Activated Sludge System (CASS) that is incorporates the subsequent stages.

2.1.1. Pre-treatment stage (Grid)

It's a mechanical stage for interference the suspended substances in sewerage, it place before waste water assortment purpose and adjustment pond to carry up the massive solid so as to avoid the dangerous influence to following treatment process.

2.1.2. Adjustment Stage

It is a pond used for the adjusting the un-regular discharge and water quality of wastewater assortment by setting the balance of water quality, and make the wastewater enter biological treatment stage with design capability.

2.1.3. Biological treatment

The biological treatment method of the system is performed by Cyclic Activated Sludge System ponds, that have totally different perform of primary sedimentation, aeration, secondary sedimentation all joined unit. It is an intermittent reaction system. In this pond active sludge process is running repeatedly between aeration and un aeration period, the bio-chemical reaction and sludge water separation process will be also finished in the pond.

2.2. Characterization of wastewater

Samples of water were obtained from sampling points of wastewater treatment plant of Khartoum Tannery and White Nile Tannery, that involve the followings:

- Stage A (untreated/treated) effluents discharged off from the tanneries.
- Stage B (adjacent pond),
- Stage C (100 m downstream) from the primary location (soil),
- Stage D (uncontaminated area) eight kilometers from industrial and domestic region

2.3. Samples analysis

The water samples and effluents sample from the stage A, stage C and stage D were collected in polythene bottles (1L) (Table 1). Soil samples were collected randomly from upper productive soil (0 to 15 cm) from contaminated (Stage C) and uncontaminated (stage D) site. The effected surface soil samples, were collected up to 50 m from the discharge point. Soil samples were cleaned from stones, pebbles, and air oven dried. Soil sample (50g) was dissolved in 100 ml of distilled water and stirred mechanically on an electric shaker for 10 minutes and allowed to settle down subsequently for thirty minutes [11,12], then the supernatant layer of the solubilized metal matrix was separated by filtration and used for direct evaluation of heavy metals using flame atomic absorption photometer (AAS) system (Perkin Elmer 5000). The effluents filtered through 0.45 filter paper then the collected filtrate was used to evaluate the content of heavy metals. Solutions were diluted with distilled water. The standard linear calibration method was applied for the quantification of metals using standard solution. Automatic background compensation was carried out by the AAS system throughout the study. SPSS software was used to compute the relevant statistical analysis of the data [13].

Table 1 Sampling location

Sample Number	Sources	Description
Stage A	(untreated/treated)	Effluents discharged
Stage B	Adjacent contaminated pond	Around industrial Area
Stage C	100 m downstream from the first location	Soil (Sediment)
Stage D	Un contaminated area	reference water sample

3. Results and discussion

Table 2 display the average metal concentrations in the effluent, pond water, soil samples, and uncontaminated water (references). The average metal concentration and their means distribution in effluent (SA) showed that Sodium (1445±392), Calcium (185±76), Magnesium (118±58.3), Potassium (96±45.31) mg/l respectively which reflecting high mean concentration. The mean concentration of metals in water samples from all stages A, B and C were found to be higher than the uncontaminated water level (SD). On the other hand, heavy metals in the effluent sample (SA) showed that, the mean concentration of Chromium (Cr), Iron (Fe), Nickle (Ni), Manganese (Mn), lead (Pb) and Zinc (Zn) were 1.686 ± 0.154; 74.27 ± 15.95; 1.106 ± 0.684 ;1.19 ± 0.66; 2.24±1.05; and 1.523±0.70 mg/l respectively. It is clear that Sodium, Calcium, Magnesium, Potassium arises as dominant metals followed by Chromium, Iron, Nickle, Manganese, lead and Zinc in the sample's stages SA, SB and SC. The concentration of these metals is highest in soil samples (SC), which is in line with previous findings of those industrial effluents discharged from the treatment plants having noxious heavy metals flows into the environment [14]. The computed standard deviation of these metals in the stage sample (SA) showed a high scattered manner around the mean concentration of metals in the effluent stage. Michaels and Lewis [15] have reported that industrial wastewater released into the environment from the treatment plant contains high concentration of salt, heavy metals and significant amounts of unspent color and smell. Comparable findings were noted in the present study where the pond water samples stage (SB) and the soil samples stage (SC) were manifestly contaminated with toxic metals. The average metal concentrations of Calcium, Potassium, Sodium, and Magnesium in the soil samples (SC) were 4660 ±2166; 2017 ± 654.5; 25576 ± 9843; 275.0 ± 129.5 and 151.3 ± 30.17 (mg/l) respectively (Table 2). Chromium average concentration in the effluent (1.686 ± 0.64) and soil (3.988 ± 1.775) sample is high compare to the pond water (0.956±0.345) and un contaminated stage, this due to a large fluctuation of metal accumulated in the soil and adjacent pond in the close region of industries (SB, SC) (Table 2). Therefor the premeditated standard deviation values associated to distribution of these metals in the soil samples display high scattering around the mean concentrations. So, the pattern of average metal concentration will be in the following manner Soil > Effluent

> adjacent pond water > Uncontaminated. This relationship indicates the role of effluents towards enhanced metal accumulation in the nearby soil system. Therefore, the possible contribution of the industrial tannery effluents towards soil and water contamination in the (SB) and (SC) area cannot be ruled out. Iron, Nickle, Manganese, Lead, and Zinc mean concentration in soil (SC) were 151.8±30.67;1.790±1.05; 3.239±1.55; 2.117±1.097; and 6.558±3.28 mg/kg respectively which indicated the degree of pollution in this area compared to uncontaminated stage. The average metal concentrations in uncontaminated water samples stage (SD) were displayed in **table 2**, which were well within WHO safe limit [6,16]. When we compare between the mean metal concentration of water samples SA and SB with that of uncontaminated SD, we noticed that SA and SB samples tend to be higher. The level of metal concentration in uncontaminated water sample stage were within the permeable level of WHO for drinking water (Figure 2).
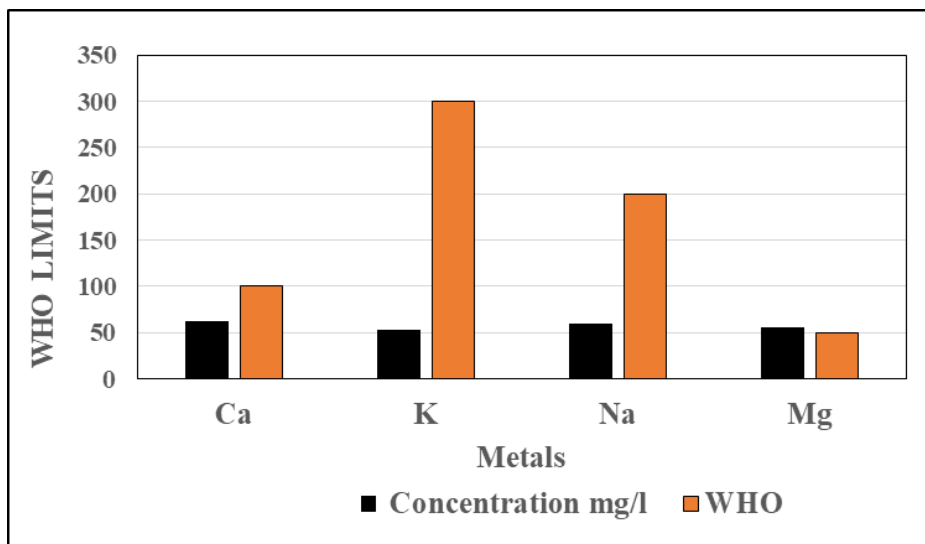

Figure 2 Metal concentration of uncontaminated water samples (mg/l) with WHO limits

Figure 3 described the chloride (Cl^{-1}) mean concentrations in effluent, pond water, and soil which shows the highest chloride concentration in effluent (144785 mg/l) followed by soil (13320 mg/l) and the water pond (320 mg/l) which explore the low chloride content. The figure also confirm that chloride content is above the permissible level (250 mg/l) prescribed by World Health Organization (WHO) (Table 2) [17]. The high chloride content this could be produced by the improper treatment of effluent in the tannery, High chloride content may cause corrosion [18].
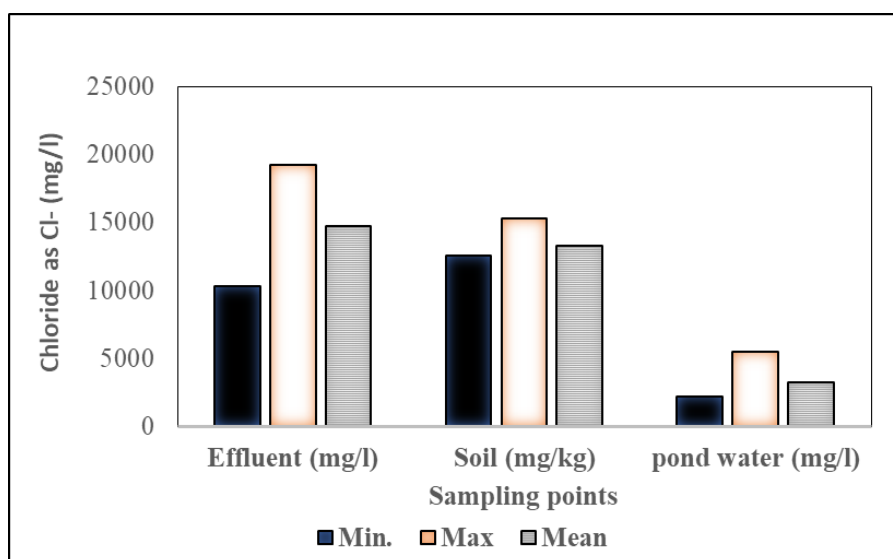

Figure 3 Chloride as Cl^{-1} level on different sampling

Table 2 Heavy metals concentration in effluents (mg/l), Pond Water (mg/l), soil (mg/kg) and un contaminated water samples (mg/l) with the permissible limit stipulated by WHO of different sources in Khartoum industrial area

Metals	Effluent (SA)				Pond Water (SB)				Soil (SC)				References (SD)				WHO
	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	
Ca	153	226	185	76	99.8	129.8	116.7	58.11	1340	8764	4660	2166	59.56	63.75	61.86	51.57	100-300
K	72.68	190	96.46	45.31	151	278	232.6	86.4	1119	2839	2017	654.5	51.98	52.65	52.39	50.75	300
Na	1171	2065	1445	392	249	446	344.8	109.8	10210	36818	25576	9843	120.0	61.00	58.99	51.12	200
Mg	83.8	148.0	118.9	58.3	79.0	143.8	107.8	73.32	151.8	399	275.4	129.5	50.35	56.75	55.736	50.81	50
Chloride	10320	19250	14785	2115	2200	5520	3210	880	12620	15360	13320	1023	1.02	1.84	1.43	0.08	1000
Sulphide	320	780	590	125	69	145	200	85	268	995	656	220	0.8	1.25	0.65	0.05	400-500
Heavy metals content																	
Cr	0.54	3.214	1.686	0.64	0.51	1.450	0.956	0.345	2.660	6.450	3.988	1.77	BDL	BDL	BDL	-	2
Fe	50.4	100.0	74.27	15.95	1.159	1.925	1.597	0.73	117.48	1420	151.8	30.67	0.51	0.55	0.525	0.51	10
Ni	0.513	1.48	1.106	0.684	0.58	1.185	0.867	0.748	0.328	3.268	1.790	1.05	BDL	BDL	BDL	-	3
Mn	0.90	1.47	1.19	0.66	0.535	0.612	0.571	0.523	1.710	5.15	3.239	1.55	0.51	0.53	0.517	0.514	0.05
Pb	1.07	2.57	2.24	1.05	0.76	1.189	0.869	0.594	1.190	3.750	2.117	1.09	0.55	0.68	0.68	0.53	0.1
Zn	0.69	2.958	1.523	1.30	0.69	1.450	0.909	0.736	2.68	9.950	6.558	3.28	0.502	0.504	0.503	0.501	5.00

BDL= Before Detectable Level- SD= Standard Deviation, all value is stated Mg/l

On the other hand, sulphate mean concentration in this study shows the highest sulphate concentration in soil (656 mg/l) followed by effluent (590 mg/l) and the water pond (200 mg/l) which is considered the lowest sampling point content (Figure 4). Sulphate content during this work is higher than allowable boundary of 500/400 mg/l apart from lake water solely aforesaid by World Health Organization (WHO) (Table 2), whose values are well inside the limit. salt is formed because of the breakdown of many Sulphur materials exist in tannery process. Large amount of salt will make destruction to pipeline, increase corrosion of steel, iron, and aluminum, yet, owed to the act of salt its worth stating in drinking water [19]. serious metals from industrial effluent unendingly disturb the environment, particularly aquatic ecosystem [20]. This study, therefore, confirmed that the soils and lake water in proximity to the industries have accumulated high concentration of venomous metals in SB, SC, and SD, with elevated levels prodigious the limit for his or her safe use set down by World Health organization [17,21].
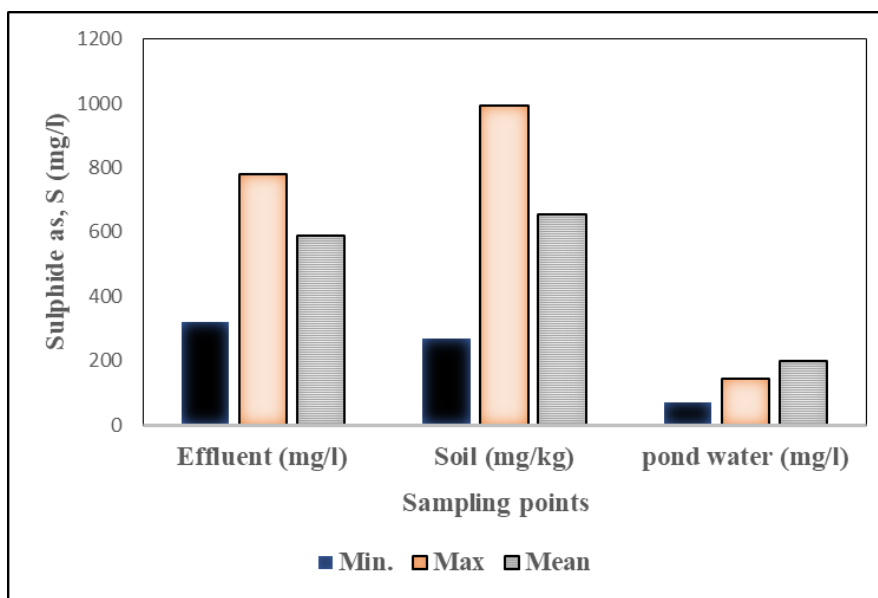

Figure 4 Sulphide as (S) level on different sampling points

4. Conclusion

The main basis of water body's contamination is unwise discharged from industries without treatment, release of raw municipal and biodegradable pollution into the water resources inflicting thoughtful contamination. From the present investigation, we are able to conclude that analysis of metals in sampling points of (effluent, pond water, soil and uncontaminated water) in south Khartoum industrial area that involve Khartoum and White Nile tanneries there are an appropriate level for Ca and metallic element in effluent, pond water, and pure water, on the other hand soil reported high concentration of metals higher than the appropriate level prescribed by World health organization (WHO), but the toxicity of harmful chemical may interfere with the extent of well water if no safety strategies were provided for operative handling of the discharged effluent. Outcomes of this study, serious metals of sampling points of effluent, pond water, soil, and uncontaminated water were higher than the permissible limits for drink of United Nations agency. we have a tendency to conclude that by employing a planned combination treatment technique, the effluents in work effluent will eventually be controlled to satisfy the stricter standards of effluent disposal. Moreover, we have a tendency to conjointly focus our efforts on use effluent.

Compliance with ethical standards

Disclosure of conflict of interest

Authors have declared that no conflict of interests exists.

References

[1] Georgiou D, Melidis P, Aivesidis A, Gimouho – Poulos K. EVALUATION OF HEAVY METALS IN TEXTILE EFFLUENTS IN RELATION TO SOIL AND POND WATER, Dyes Pigments. 2002; 52: 69- 78.

[2] Tsui LS, Roy WR, Cole MA. Removal of dissolved textile dyes from wastewater by a compost sorbent, Colouration Technology. 2003; 119: 14-18.

[3] Doulat Ardejani F, Badii Kh, Yousefi Limaee N, Mahmoodi NM, Arami M, Shfaci SZ, Mirhabibi AR. Numerical modelling and laboratory studies on the removal of Direct Red 23 and Direct Red 80 dyes from textile effluents using orange peel, a low-cost, Dyes Pigments. 2007; 73: 178-185.

[4] Vander Gaag MA, Storelder PBM, Vander kooy LA, Bruggeman WA. Water quality problems in Slovenia Eur. Water pollt. Cont. 1991; 1: 13- 18.

[5] Remyla SR, Mathan R, Kenneth SS, Senthilkumar K. Influence of zinc on cadmium induced haematological and biochemical responses in a freshwater teleost fish Catla catla Fish Physiol. Biochem. 2008; 34: 169-174.

[6] Manzoor S, Shah MH, Shaheen N, Khalique A, Jaffar M. Multivariate analysis of trace metal levels in tannery effluents in relation to soil and water: A case study from Peshawar, Pakistan : J. Haz. Mat. 2006; A137: 31-37.

[7] Nragu JO, Wong HKT, Lawson G, Daniel P. Saturation of ecosystems with toxic metals in Sudbury basin, Ontario, Canada: Sci. Total Environ. 1998; 223: 99-117.

[8] Dulkadiroglu H, Dogruel S, Okutman D, Kabdasli I, Sozen S, Orhon D. Effect of chemical treatment on soluble residual COD in textile wastewaters: Water Sci. Technol. 2002; 45: 251-259.

[9] Alaton IA, Kornmuller A, Jekel MR. Ozonation of Spent Reactive Dye-Baths: Effect of HCO3-/CO32- Alkalinity: J. Environ. Eng. ASCE. 2002; 128: 689-696.

[10] De Moraes SG, Freire RS, Duran N. Degradation and toxicity reduction of textile effluent by combined photocatalytic and ozonation processes: Chemosphere. 2000; 40: 369-373.

[11] APHA, AWWA, WPC, Standard methods for the examination of water and wastewater, 20th ed. APHA, AWWA, WPC Washington DC, USA. 1998.

[12] Tessier A, Campbell PGC, Bisson M. Sequential extraction procedure for the speciation of particulate trace metals: Anal. Chem. 1979; 51: 844-851.

[13] SAS institute Statistical 'Users Guide, release 6.03 edition SAS institute, Inc., Cary NC. 1988.

[14] Breckenridge RP, Crocket AB. DETERMINATION OF BACKGROUND CONCENTRATIONS OF INORGANICS IN SOILS AND SEDIMENTS AT HAZARDOUS WASTE SITES: US. Environmental protection Agency, Washington DC. E.A 540/S-96/500, 32. 1995.

[15] Michaels GB, Lewis DL. Sorption and toxicity of azo and triphenylmethane dyes to aquatic microbial populations. Environmental Toxicology and Chemistry: An International Journal. Feb 1985; 4(1): 45-50.

[16] Sevket kandemir, Dogru MI, Orun I, Dogru A, Altas L. Determination of heavy metal levels, oxidative status, biochemical and hematological parameters in Cyprinus carpio L., 1758 from Bafra (Samsun) fish lakes. J. Animal Veterinary Advances. 2010; 9(3): 617-622.

[17] WHO? Guidelines for drinking water quality, 2nd edition, Volume 3, Surveillance and control of community supplies, World Health Organization, Geneva. 2008; 58-61.

[18] KA Yusuf. Evaluation of ground water quality characteristics in Lagos-City. Journal of applied Sciences. 2007; 7(13): 1780-1784.

[19] PK Jena, M Mohanty. Processing of liquid effluents of mineral processing industries, Intl Symposium Environ Manag Mining Metallurgical Industries, 11-14, Bhubaneshwar. 2005; 193-212.

[20] Zafar Ayas, Guler K, Sedat VY. Muratozmen Heavy metal accumulation in water, sediments and fishes of Nallihan Bird Paradise, Turkey: J. Environ. Biol. 2007; 28(3): 545-549.

[21] USEPA, Ground water quality standards, Fed. Regist. Superintendent Docum 65. 2000.