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ASSESSMENT OF TANNERY BASED SOLID WASTES MANAGEMENT IN ASILI, NAIROBI KENYA

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Abstract: *Solid wastes generated in Nairobi and its environs are posing a serious environmental challenge to the authorities and public, especially the hazardous and non-biodegradable solid wastes from leather industries. There were environmental concerns and complaints from workers and residents living adjacent to Asili tanneries limited about degradation of natural and inbuilt environment. This pointed to the effect of environmental pollution by the tannery. The broad objective of study was to assess the effectiveness of tannery based solid wastes management, by identifying and analyzing the concentration levels of sodium chlorides, sulphide, chromium ions and total phenols as selected pollutants along the tanning stages, in Nairobi river, borehole water, and soils around the dump site inside the tannery. Experimental (laboratory analysis) design was used. Descriptive statistics was used in analyzing data resulting in means and tables. The means concentration of total Chrome was 2633.38mg/L, Sodium chloride 609.93mg/L, Sulphide 129.77mg/L, total Phenols 10.91mg/L in the soil sampled around the composite dump site.. In Nairobi river water the means of Sodium chloride was 317.48mg/L, Sulphide 24.00mg/L, total Phenol 3.97mg/L and total Chrome Nil, While means concentration in borehole water, had Sodium chloride detected at 354.73mg/L, Sulphide 6.67mg/L, total Phenol 0.03mg/L and total Chrome as Nil, indicating heavily contaminated ecosystems above the discharge set limits of National Environmental Management Authority and Nairobi city water and sewerage company.*

Keywords: *Tanning processes, Tanning pollutants, Dump sites, Crude dumping, Environment*

1. Introduction

In search of a covering material for himself, his hut and food, early man turned either to large leaves from plants or to the skins of the animals he killed. The skins were chosen for clothing as they were bigger, stronger and warmer. However, they soon putrefy if left in a damp condition. Dried skins/hides on the other hand lost flexibility and softness becoming very hard and brittle leading to cracking which is unsuitable for clothing and other uses. To stop all these, early man discovered tanning technology which

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converts hides and skins into leather which do not putrefy even after drying and wetting back. (Sharphouse, 1971).

The environment is under increasing pressure from solid and liquid wastes emanating from the leather industry. These are inevitable by-products of the leather manufacturing process and causes significant pollution unless treated in some ways prior to discharge (Bosnic *et al*., 2009). The solid wastes generated during leather processing are significant since leather industry makes uses of only 20 -25% of the raw material in the finished leather, 75 -80% end up as wastes in the environment (Page, 2005). Since these wastes contain hazardous chemicals, they pose a risk to the environment because leather and leather products are non-biodegradable and contain toxic chemicals which become mobile after synergies in the environment thereby posing pollution threat to several ecosystems where they are discarded (Winters, 1979).

Environmental issues of leather industry in Africa are water pollution due to dumping of waste in rivers, lakes, and air pollution from hydrogen sulfide, ammonia gas and bad odors from tanneries, land pollution and poor management of solid wastes (TDLIA, 2002). In Kenya there are 13 commercial tanneries operating currently at 70% capacity (MoLD, 2010). Their daily production is 40 million tones. In 2009 the production figures of hides and skins in the country were 2.9million cow hides, 2.8 million goatskins, 3.2million sheepskins and 0.6million camel hides. These were either exported raw or tanned into leather locally and were ;-: wet blue. (46,151,080 square feet), crust leather (754, 071 square feet) and finished leather (nil) (MoLD, 2010). Out of the above production figures, Asili Tanneries limited produces 4 tons of hides and 4.5 tons of skins daily (Asili, 2011). Out of that production figures above, it was averaged that Asili tanneries limited produces 10 tons of solid wastes per day which were disposed into the environment (Asili, 2011). These solid wastes posed a real challenge to the environment unless sustainable management of containing them is put in place, therefore in this paper, the presence and concentration levels of selected pollutants along tanning stages and in the ecosystems within and outside the tannery were analyzed to confirm the effectiveness of their management and postulate their possible impact on the quality of life.

2. Materials and methods

2.1. Laboratory analysis for collected samples

Primary data from the sampled wastes were collected and analyzed through Society of Leather Technologist and Chemist official methods of analysis Amendment March (SLTC, 1996) and the standard methods of water and waste water, America Public Health Association (APHA,1998) at Kenya Industrial Research and Development Institute (KIRDI) in Nairobi, which has accredited laboratories.

Samples collection, preservation, handling and laboratory analysis from the tanning stages.

The samples for laboratory analysis were collected from the tanning stages using clean polythene bags. They were all collected three times with their duplicates and controls (raw skins). This procedure provided a chance for second round of analysis to clear any doubts and control to the analysis. As a precaution, the collected samples were transported under cool box the same day and stored in the dark at 4^oC and later tested as follows:-

Selected pollutants present in lime fleshings from beam house, shavings from tan yard operation, buffing from crust and finishing yard operation and raw skin as a control.

They were randomly sampled from beam house, tan yard, crust and finishing yard weighed, dried and milled to make an extract. pH of the extract was measured using pH meter. Sodium chloride, sulfide and chromium concentrations were determined through titration methods (SLTC, 1996). APHA (1998) detailed procedures using UV model win 50 carry UV spectrophotometer was used for total phenols. Values were then calculated and recorded.

2.2. Samples collection, preservation, handling and laboratory analysis from the Ecosystems

All water samples for analysis were collected from upstream and downstream parts of Nairobi River and borehole water inside Asili tannery using clean air tight bottles that were filled to the brim and capped without air bubbles. Control was tap water drawn from inside the tannery and supplied by Nairobi City Water and Sewerage Company. They were transported under portable cool box and stored in the dark at 4^oC and later tested as follows

River, borehole and tap water analysis for selected pollutants.

To analyze for the selected pollutants concentration levels in water horizontally, a half a litre sample of water with duplicate was collected at 10m upstream (to exclude non-point sources of pollution upstream) and at 10m downstream after leachate from the composite dump site had drained into the Nairobi River from 30m away while vertical pollution due to seepage and percolation was analyzed from borehole water 10m away. Borehole was 150m deep (key informant). A minimum of three samples with their duplicates and controls were analyzed.

The pH of the Water was taken at the sampling point using portable pH meter. Chromium (iii) concentration was analyzed and determine by aspirating the sample into the Atomic absorbance spectrophotometer machine model AA 3600 Schimadza. Sulphide and Chlorides were analyzed by titration method. Total phenols were analyzed using UV model win 50 carry UV spectrophotometer (APHA, 1998).

Soil analysis around the dump site (within Asili), and outside the gate as a control for selected pollutants

Randomly sampled soil for analysis were collected from different sites around the composite dump site using stainless steel hand trowel and clean plastic containers while the controls were collected from outside Asili tannery gate. This was done after an interval of time (7-14 days) when the wastes from the tanning stages dumped at the composite site were assumed to have undergone some treatments and biodegrading before their eventual disposal to Dandora dump site. The above precaution was taken into consideration with the samples.

To analyze for the selected pollutants concentration levels in the soil, a half kilo sample of soil with duplicate was taken at 30m radius and 10cm deep from the soil surface around the composite dump site. A minimum of three samples with their duplicates and controls was analyzed. The samples for laboratory analysis were weighed, dried, crushed/grounded, mixed thoroughly and sieved with 2mm mesh size to form an extract. Then it was dissolved in distilled water to make a solution that was used for analysis.

Chromium (iii) concentration was analyzed by aspirating the sample into the Atomic absorbance spectrophotometer machine model AA 3600 Schimadza. Sulphide and chloride presence was analyzed by titration methods. Total phenol was analyzed by using UV spectrophotometer (APHA, 1998).

3. Data analysis

The data from the laboratory was analyzed by descriptive statistics that calculated their means and then compared the same with set standards. A table was used to present the findings. This was corroborated with photographs taken around the dump site.

4. Results and discussions

The assessment of tannery based solid wastes management in Asili tannery using laboratory analysis of samples collected along the tanning stages, soil, waters and then analyzed for the presence and concentration levels of selected pollutants established the data given in the tables 1 and 2 below.

Table 1 gives the means concentration of selected pollutants sampled along the tanning process.

Table 1. Average mean concentrations of the selected parameters measured from the samples collected along the tanning stages

Test	*Raw dried skin (control)*	*Lime fleshings*	**Shavings**	**Buffings**
pH	6.2	8.5	4.9	5.1
Sodium chloride (ppm)	33,000	82,000	28,000	18,000
Sulphide (ppm)	*ND*	*17000*	*Trace*	*ND*
Chromium (ppm)	ND	ND	33000	28000
Total phenol (ppm)	620	20	10	200

17000 ppm sulphide was present in lime fleshings. This may be normal because sodium sulphide was used in liming process to cause unhairing to the “skins”. Traces were found in shavings and wet blue. This may be explained by the fact that there are different types of deliming processes depending on the kind of tannage to be carried out and finished leather desired (Sharphouse, 1971). No sulphide was detected in the buffing dust suggesting that sulphide was not used in the crust and finishing yard.

33000 ppm chrome was detected in the tan yard. 28000 ppm was found in buffing dust from crust and finishing yard. This may be attributed to the chrome tanning and retannage processes where chrome was used as a tanning agent. Chrome’s presence was not detected in the beam house stage. This may suggest that chrome is used in tan and crust finishing yards stages only and agrees with the principles of leather manufacture. (Sharphouse, 1971).

Sodium chloride was detected in all samples analysed. The highest concentration was found in lime fleshings at 82000 ppm followed by raw skin at 33000 ppm Shavings and trimmings had 28000 ppm while buffing had the least at 18000 ppm. The explanation was that in raw skin, salt presence was from the natural salt in the skin and contamination during handling in the purchasing area. In the beam house, industrial salt was used as a deliming agent. In the tan yard salt was used in pickling as buffer against sulphuric and formic acids and in the fixation of chrome during basification process. In crust and finishing yards salt was used as buffer in the retannage and some dyes and lacquers contained salts as part of their composition The above suggestions were supported by tanning recipes obtained from the tannery Asili tanning recipe (2011).

Total phenol was found highest in raw skin at 620 ppm. This may be due to the use of doom/greenman powder sprinkled on raw skin to prevent moulds growth and insects infestation during storage in the go-down/stores before tanning. According to key informants, air dried skins need to be dusted with insecticides which had the phenols derivatives in their compositions. The high percentage may be due to application methods employed by the store owners, who dusted raw skin without measuring the quantity applied in proportion to the weight of the skin.

The buffing had 200ppm of total phenol and this may be attributed to the presence of phenols in the syntans, dyes, fatliqours, resin, and lacquers used for retannage and finishing processes .20ppm found in the lime fleshings came from the tanning recipe where Busan was added as a preservative along with tanning chemicals to pelts in the soaking and liming operation units to prevent fungal/moulds growth. 10ppm was found in shaving and trimmings from the tan yard where anti- fungal was added to wet blue leather destined for export to prevent their attack during the shipment to overseas tanneries for further tanning and finishing (Sharphouse, 1971; Asili tanning recipe, 2011).

Sodium chloride and total phenols were the most frequently detected pollutants in the samples analysed from all stages. Chromium and Sulphide presence was restricted to certain stages of the tanning process. The presence of selected pollutants on sampled wastes along the tanning process, confirmed that the solid wastes generated from tannery were likely to contain these hazardous chemicals and may pollute the environment and lower the quality of life, if disposal methods in use was ineffective. The concentration levels varied from different stages of tanning process but confirmed the presence of selected pollutants in the wastes generated.

Table 2. Average means concentration of selected pollutants analysed from sampled soil and waters within and near Asili tanneries limited

parameter	Control soil	soil	control water	Borehole water	Upstream water	Downstream water	NEMA Stds	NCWSC Stds
pH	7.82	8.25	7.49	7.76	6.87	6.86	6 - 9	6 - 9
Chromium ppm(mg/l)	***28.09***	***2633.38***	***ND***	***ND***	***ND***	***ND***	2.0	0.1
Total phenols ppm(mg/l)	***7.18***	***10.91***	***0.23***	***0.03***	***1.40***	***3.97***	0.2	2.0
Sulphide ppm(mg/l)	ND	129.77	9.30	6.67	25.33	24.00	2.0	0.1
Sodium chloride ppm(mg/l)	***18.4***	609.93	***74***	354.73	281.11	317.48	250	75

4.1. Total Chrome

Chromium presence in the environment exceeded NEMA set standard of 2.0 mg/l in soil sampled around dump site by 2631.38mg/L. Nothing was detected in both waters. This agrees with Karim *et al.* (2013) whose analyses in the Hazaribagh tannery indicated that the site was extremely polluted by Cr (up to 37,000 mg/kg dm). Kanagaraj *et al.* (2010) explains that Chrome (iii) do not migrate at disposal land sites, thus the high concentration levels detected.

Absence of total chrome in groundwater samples in this study conforms to Karim *et al.* (2013) findings of Tubewells in the Hazaribagh area, where groundwater was not contaminated by Cr or any other heavy metals. None detection of total chrome in river water in this study was well captured by Mwinyikione (2010) explanation that heavy metals tend to be deposited in the sediments when they filter out along the river course. The above explanation justify why chrome was high in soil around dump site but returned nil from river and bore hole waters. This raised concerns about the presence of Cr^{+6} which is carcinogenic. The high levels detected may be of concern to public health authorities as cases of cancer have been on the increase in recent days in the country. Hayes, (1997) and Kolomaznik *et al.* (2008) explains further that Cr^{6+} is more soluble than Cr^{3+} at pH range of 5-7 and reacts with cell membranes. The target organ for acute systematic toxicity is the kidney. Poisoning by Cr^{6+} results in acute necrosis of the kidney and even cause of death. Prolonged contact with kidney may produce allergic reactions and dermatitis in individuals thus the negative impacts of tannery based solid wastes on quality of life especially workers and residents living adjacent to the tannery currently or in future.

Next to the study site were found food crop like kales, cassava, banana, maize and Napier grass being grown for human and livestock consumption. The high concentration levels of chrome in the soil, as a pollutant may led to its conversion into organic form which can easily biomagnifies/bioaccumilate along the trophic levels, exposing workers, residents of Njiru and their livestock to high risk of carcinogenic effect either directly or indirectly as seen in plate 1. In Italy and Sweden 20-30% cancer risk were found among tannery workers according to Kolomaznik *et al*., (2008). Further studies have also shown that even finished leather products—especially those in direct contact with the skin, such as gloves or shoes—contain high levels of a toxic chemical - hexavalent chromium, considered to be a strong allergen that can lead to skin reactions like eczema (Hayes, 1997). Workers in Asili may need regular medical checkups to confirm whether their health is not under threat or compromised by the exposure.

Figure 1. (1a) .A worker picking kales. (1b) and (1c) cassava and Napier grass grown next to the dump site

Figure 2. (2a) a vehicle overloaded with wastes. (2b) chrome droppings observed along the road from Aziz tanneries limited

Presence of total chrome in the control soil outside Asili may be suggested to have originated from occasional droppings along the way from open overloaded transporting vehicles as seen in plate 2. Since chrome last longer in the environment it was possible to detect its presence even after a long period as Kolomaznik *et al.*, (2008) states that "Chromium substances persist in the environment beyond 20 years". Andrew *et al.*, (2010) suggests that contaminated soils from such pollutants need remediation, excavation and removal as cost-effective measures to break the pathway between the contaminant and the local population and then construction of a waste treatment facility and secure landfill to contain them. Failure to put those measures in place is likely to expose the public to the potential entrance of chrome through skin and other organs posing a serious threat to public life of present and future generation who might come in contact with the tannery based solid wastes.

Total phenols

Total phenols was found present in sampled soil at 10.71mg/L above NEMA set standards of 0.2mg/l.. The total phenols pollutants may have spread to the soils through crude dumping at site or spillage during transfer period. Total phenols containing wastes from the finishing yard that were in dust or fumes/vapour forms, might have been blown by wind/evaporation to the soil. Nor Suhaila *et al.,* (2010) and Marrot *et al.* (2006) suggests that such ecosystems may require bioremediation as the environmentally friendly and cost effective method of controlling phenols impacts on the environment beyond the recommended discharge levels.

Water sampled from the river had total phenols detected above NEMA/NCWSC set standards at 2.77mg/L and 1.97mg/L respectively. Statistically no significant difference was found between the means of upstream and downstream river waters analyzed ($t = 0.716, p \leq 0.05$). This implies that none point sources of pollutions and the tannery were equally polluting Nairobi River. This disagrees with Mwinyikione *et al.,* (2005) that "the characterization results of the Kenyan tannery effluent demonstrated that all of the pollutants observed downstream (but not upstream) emanated from the tannery site.

The least polluted ecosystem measured was the Borehole water that had 0.03mg/l of total phenols detected below the set standards. The persistence of phenols in the environment is a source of environmental concerns Phenolic compounds exert toxic effects on micro-organisms disrupting energy transduction either by uncoupling oxidative phosphorylation or inhibiting electron transfer. This reduces the biological biodegradation of the other components and makes the degradation of phenols also difficult in the environment explains Mwinyikione *et al.,* (2005). The above explanation means that phenols can last longer in the environment and affects the biogeochemical services thereby interfering with natural functions of the ecosystems and affecting human health as stated by Nor Suhaila *et al*., (2010) "that Phenol compounds are toxic either by ingestion or by contact or inhalation even at low concentrations. Acute exposure of phenols causes central nervous system disorders, which leads to collapse and coma. Muscular convulsions with significant reduction in body temperature are also noted due to phenol toxicity, and this is known as hypothermia. Renal damage and salivation may be induced by continuous exposure to phenols.

Sulphide

Sulphide presence was beyond NEMA set standard of 2.0 mg/l in sampled soil by 127.77mg/l. Sulphide is known to oxidize faster in the environment when aerated to dry but the high concentration levels observed in the sampled soil could only be justified by its proximity to dump site. This is where huge amount of tannery based solid wastes, regularly generated, compiled and compacted by the lime fleshings, other wastes, the soil structure and natural degrading capacity of microbes could not cope with the rate of generation thus the high presence of sulphide.

Downstream, 23.90mg/L /22.00mg/L above NCWSC/ NEMA set limits was detected in the river water ,while Borehole water exceeded values was analyzed at 6.57mg/L / 4.67mg/L for NCWSC/ NEMA respectively. According to Hwa *et al.,* (2007) solid wastes dumping is the source of (hydrogen sulphide gas) that in the presence of moisture give off organic and inorganic contents which turn into leachate, whose huge amount percolates through the surface and contaminates the groundwater increasing the risk of polluting the underground aquifers because of lack of provision for their removal or treatment. In this study borehole water was next to the composite dump site therefore leachates from the lime fleshings containing sulphide pollutants may have seeped laterally into the water aquifer underground and horizontally into the river by either run off or percolation and contaminated them. The primary biochemical effects arising from hydrogen sulphide exposure are inhibition of the cytochrome oxidase and other oxidative enzymes resulting in cellular hypoxia or anoxia according to Mwinyikione, (2010).

Prolonged exposure to (250-500mgl-) result in olfactory paralysis, severe lung and eye irritation, pulmonary oedema and unconsciousness in human as explained by Mwinyikione, *et.al*., (2005). Clinical effects are consistent with organic brain disease resulting from anoxia and thus may persist for several years after the initial exposure states Mwinyikione, (2010). Hydrogen sulfide formed due to the presence of sulfide in the effluent and chromium is highly toxic to many forms of life. Some workers died in Karachi in 1980 while clearing monsoon ditches filled with tannery sludge reports Shahrukh *et al.* (1999). In Kenya it was reported by the senior leather development officer at Kabete that 4 workers died at Athi River town while trying to clear a blocked tannery ditch

High concentration levels detected in river upstream was 25.23mg/L / 23.33mg/L above NCWSC/NEMA set standards of 1.0/ 2.0 mg/l respectively suggesting the origin to be from other sources of pollution upstream, but as the water flowed downstream it underwent the dilution effect and decreased in concentration, implying that health of people downstream might not be in danger but analysis may be required in future to ascertain the extent of dilution process.

Sodium chloride

It was established in this study that salt was one of the solid wastes generated and dumped at site. This was suspected to be increasing salt content in groundwater, surface water and even the soil making it become a serious environmental issue. Sodium chloride pollution of the environment was found too high beyond the NEMA set standard of 250 mg/l in soil near dump site by 359.93 mg/L. This concurred with Ozgunay *et al.*, (2007) findings that high salt in solid wastes increases salt in the soil at storage site.

In borehole water the values exceeded by 279.73mg/L for NCWSC (threshold limit is 50mg/l) and 104.73mg/L NEMA standard. Buljan *et al*. (2011) explains that increased salt content in groundwater, especially in areas of high industrial density, is now becoming a serious environmental hazard. When flushed from the soil by rain, chlorides re-entered the eco-system and ultimately ended up in the groundwater.

In Nairobi River, upstream concentration levels of sodium chloride exceeded NCWSC set limits by 206.11mg/l and NEMA standards by 31.11mg/l. Downstream water was 242.48mg/l higher for NCWSC threshold and 67.48mg/l for NEMA standards. Huq (1996) recorded similar results whereby tannery effluents heavily polluted river Buriganga water with high chloride content. High sodium chloride concentration can affect aquatic plants and invertebrates as noted by Mwinyikione *et al*., (2005) EPA has set a secondary maximum contaminant level (SMCL) for sodium of 250 mg/L based on organoleptic issues, i.e., it compromises the taste of the water but drinking water requires salts below 250mg/l, therefore the groundwater in this study had a higher concentration values than the set limit while the surface water was below the drinking water set limits.

EPA now requires monitoring and has set a drinking water limit of 20 mg/L for sodium above which public water systems must report the concentration to local health authorities, making it an environmental threat to human life as noted by Siegel, (2007). Excess sodium has been linked to hypertension, which is high blood pressure identified as greater than 140/90 that has driven EPA's limit. This condition is of concern because, if left untreated it can lead to cardiac disease, renal disease, hardening of the arteries, eye damage and stroke. Approximately 25% of the adult US population has hypertension as explained by Siegel, (2007). Fisher and Pearce, (2009), put it that there is a need to consider low salt in the preservation of green skins and recycling of lime liquors to reduce the amount disposed into the environment.

The above findings compares well with previous Environmental Audits by the company for 2012/13, 2010/11, 2008/9 submitted to NEMA and NCWSC analysis report of 2009. The reports found the discharges above the recommended levels. Shahrukh *et al*., (1999) states that "lack of effective implementation of legislative control have further aggravated the pollution problem caused by the tanning industry in the South Asian region including Pakistan".

Mainuddin (2003) states further that, because of the acknowledged hazards of leather production, the process are being discontinued in most European countries and the U.S.A and operations are moving overseas. As a result, the health of people in other parts of the world is now threatened by the tanning industry as leather industry is considered more harmful to the environment than the textile, medicine, fertilizer and paper industries states Hayes, (1997). As is the case with all industries, the poorest are the worst affected by the pollution. First, for generations, leather related jobs are done by the lower castes. Second, the competition for such jobs is so intense that the manufacturers don't have to improve the dangerous working conditions. Third, the emissions affect those living around industrial sites in low value land that have the least political power explains Shahrukh *et al*., (1999). The same could be happening in Nairobi, if the management in Asili is not effective and solid wastes are allowed to contaminate the environment within and without Asili.

5. Conclusion

The study concluded that; -The Sodium chloride and Total phenols pollutants were found common in all the tanning stages with high concentrations levels detected in beam house at 82000ppm and 620ppm respectively while Chromium was detected in tan yard, crust and finishing yard where concentration level was high as 33000ppm. Lastly sulphide was restricted to beam house stage with high concentration level detected at 17000 ppm after treatment along the tanning processes. The waters sampled after treatment of solid wastes within Asili tanneries limited for selected pollutants had sodium chloride detected at levels of 317.48ppm above NEMA/NCSWC thresholds. From the same samples sulphide levels analyzed was 24.00ppm beyond NEMA/NCSWC set limits. Total phenols presence in the water was detected at 3.97ppm above the required limits of NEMA/NCSWC. Lastly chromium registered Nil in the waters sampled. The soils sampled after treatment of solid wastes within Asili tanneries limited for selected pollutant found chromium levels at 2633.38ppm above NEMA/NCSWC set limits. The same sample had sodium chloride detected at 609.93ppm above NEMA/NCSWC threshold. Sulphide presence in the soil was found at 129.77ppm above NEMA/NCSWC set limits. Lastly total phenol registered a value of 10.91ppm above the NEMA/NCSWC standards. This is an indication that tannery based solid wastes from Asili tannery that contained hazardous chemicals may end in the ecosystems where they are likely to limit the biodegradation processes and reduce the quality of those life supporting systems.

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References:

Andrew Mc Cartor J.D., & Dan, B.A. (2010). Top Six Toxic Threats. *Blacksmith institute*, (646), 74200200: 39-44.

Asili Tanneries Limited (2011). *Management annual Report for the year 2010.* Nairobi Kenya.

Bosnic , M., Buljan, J., & Daniels, R.P. (2009). *Pollutants in tannery effluents, Definitions and environmental impact, limits for discharge into water bodies and sewers.* UNIDO Regional Programme for Pollution Control in the Tanning Industry in South-East Asia. US/RAS/92/120. 1-14.

Buljan, J., Kral, I.G., Clonfero, M.B., & Schmel, F. (2011). *Introduction to treatment of tannery effluent*. UNIDO Vienna International centre .P.O. Box 300, 1400, Vienna Austria. Retrieved from: http/.www.unido.org

Environmental Management and Coordination Act (EMCA) (2006). *Waste Management Regulations*, Kenya gazette supplement number *69.*

Fisher, H., & Pearce, D. (2009). *Salinity Reduction in Tannery Effluents In India And Australia.* ACIAR Impact Assessment Series Report No. 61:53 pp.

Hayes, R.B. (1997). *The Carcinogenicity of Metals in Humans*. *Cancer Causes and Control*. www.peta.org/issues/animals used for clothing/wool.

Huq, I.S.M. (1996). Critical environmental issues relating to tanning industries in Bangladesh. *Department of Soil Science, University of Dhaka, Dhaka 1000, Bangladesh Geography journal*, 13, 8-9

Hwa,T.J., & Bhuiya, A.G.M.J. (2007). *Report of the APO survey on solid waste management 2004-2005*. Asian Productivity Organization. Retrieved from: www.apo-tokyo.org.

Kanagaraj, J., Velappan, K.C., Chandra, B.N.K., & Sadulla, S. (2010). Solid Waste Generation in the Leather Industry and Utilization for Cleaner Environment. *Scientific and industrial Resources, 65*, 541-548.

Karim, M., Mansheven, S., Islam, M.G., Ibarra, J.M., Diels, L., & Rahman, M. (2013). Assessment of an urban contaminated site from tannery industries in Dhaka city, Bangladesh. *I. Hazard Toxic Radioact waste*, *17*(1), 52-61.

Khandaker, M., & Islam Sharif, M. (2003). *Country Case Study on Environmental Requirements for Leather and Footwear Export from Bangladesh.* Bangladesh centre for advance studies.

Kolomaznik, K., Adamek, M., Andel, I., & Uhlirova, M. (2008). Leather Waste-Potential Threat to Human Health and a New Technology of Its Treatment, *Hazardous Material (Elevier)*, *160*, 514-520.

Marrot, B., Barrios, A., Martinez, M.P., & Roche, N. (2006). Biodegradation of High Phenol Concentration by Activated Sludge in an Immersed Membrane Bioreactor. *Biochemical Engineering 30*, 174-183.

Mwinyikione, M. (2010). *Ecological Diagnosis in the Tanning Industry*. Retrieved from: http://www.springer.com/978-1-4419-6265-2,

Mwinyikione, M., Norval, J.C.S., Meharg, A., & Kiiham, K. (2005). Ecological Risk Assessment of the Kenyan Tanning Industry. *JALCA, 100*, 380-388.

Mwiyikione, M., Meharg, A., Dawson, J., Norval, J.C.S., & Killham, K. (2005). An Ecotoxicological Approach To Assessing The Impact of Tanning Industry Effluent on River Health. *Environmental contamination toxicology*, 50, 316-324.

Nor Suhaila, Y., Ariff, A., Rosfarizan, M., Abdul, I., Ahmad, S.A., Norazah, M.N., & Shukor, M.Y.A. (2010). *Optimization of Parameters for Phenol Degradation by Rhodococcus UKM-P in Shake Flask Culture*. Proceedings of the World Congress on Engineering, London, I WCE**,** June 30 - July 2.

Ozgunay, H., Colak, S., Mutlu, M.M., & Akyuz, F. (2007). Characterization of Leather Industry Wastes. *Environmental Studies*, *16*(6) 867-873.

Page, C. (2005). Understanding Clean Technology, *Leather international magazine*. *207*(4753), 17-23.

Shahrukh, R.K., Mahmood, A.K., Abdul, M.K., Haider, G., & Islamabad, S.K. (1999). *Environmental Impacts and Mitigation Costs Associated with Cloth and Leather Exports from Pakistan.* IISD/IUCN/IDRC Project on Building Capacity for Trade and Sustainable Development in Developing Countries. 13-23.

Sharphouse, J.H. (1971). *Leather technician handbook*. Leather producers association publishers London. 3-266.

Siegel, L. (2007). *Hazard Identification for Human and Ecological Effects of Sodium Chloride*. Road Salt State of New Hampshire Department of Environmental Services Water Division Watershed Management Bureau. 6

Winters, D. (1979). *The Kenyan leather industry its environmental impact and measures to mitigate such environmental degradation*. Ministry of water commissioned research.

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