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Taxidermy effluent characterisation: A case study in the City of Tshwane

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Abstract

South Africa is a well-known destination for both domestic and international trophy hunters. Taxidermies, which are mainly located near hunting farms, process the carcasses of hunted animals to produce game trophies. Processing of skins and skulls produce effluents containing chemicals which could pose environmental risks. Furthermore, data about the quantity and quality of taxidermy effluents are scarce. This study focused on a taxidermy workshop on the outskirts of Tshwane, South Africa, that discharged its effluent into an evaporation pond known to emit bad smell. Over a two-year period, COD, chrome, chloride, fats and oils, sulfates, salt, pH and electrical conductivity were measured in the effluents from the various processes. During the same time period, the volumes of water used in each of the treatment processes were calculated. The concentrations of pollutants in the final effluent were determined using a mass balance approach. The concentration of major pollutions in the effluent were as follows: 11 035.60 mg O_2/L (COD), 469.78 mg Cr/L, 1 635.79 mg fats and oils /L. The pH and electrical conductivity ranged between pH 3.2 - 7.9 and 120 - 9 741 mS/m, respectively. The volume of the effluent produced was ca 34 m3/a, which resulted in mass loads of 372.34 kg COD/a, 15.85 kg Cr/a, and 55.19 kg fats and oils/a. If these pollutants were discharged into a large waterbody, they would be diluted, however the high concentrations of COD, fats and oils, and Cr pose serious environmental risks. The high COD, fat, and oil concentrations below the effluent outfall would result in anaerobic conditions which might harm the aquatic environment. Chromium (III) could accumulate to toxic levels in the environment. As a result, it is recommended that the effluent be treated to remove fats and oils and to reduce COD and chromium levels.

Key words

Taxidermy effluent, Production of animal trophies, Water pollution

1. INTRODUCTION

South Africa has a significant number of different wild animal species which can be hunted, making it a popular destination for foreign trophy hunters. According to the Professional Hunters Association of South Africa (PHASA) about 7 500 foreign hunters visited South Africa in 2005 [4]. Moreover, based on the results of a survey conducted by PHASA in 2017, 86% of trophy hunters were from the United States of America [11].

The number of hunters was expressed as a percentage and their contribution to the South African economy through trophy hunting had increased to approximately R1,98 billion from R410 million in 2005 ([11],[4]). The trophies are produced from hunted animal carcasses, which are then processed into game trophies at a taxidermy workshop. For display, game trophies are usually fully tanned skins and/or mounts such as full, half, and shoulder in a lifelike manner. This includes the treatment of skulls (bones), horns/antlers, hooves, claws, teeth [12]. Furthermore, the taxidermy industry is estimated to contribute approximately R1,5 billion towards the South African wildlife economy, as wildlife hunted elsewhere in Africa is also processed in South Africa [22].

As of 2017, there were 150 registered taxidermies in South Africa, with 80 000 trophies exported [22]. There are 17 registered and active taxidermies in Gauteng [13]. Taxidermies that do not engage in import and export are not required to register with the National Department of Agriculture and Forestry, hence, the total number of taxidermies in South Africa is unknown [15]. Effluents from taxidermies could be high in organic biodegradable matter, dissolved salts, oils and fat and chromium considering the treatment processes and chemicals commonly used to produce these trophies. These taxidermies are usually situated close to game farms, in rural areas or on the outskirts of cities and towns, and are not always connected to wastewater treatment plants. Considering the treatment processes involved in the production of game trophies, effluents from taxidermies pose serious environmental and health risks. The monitoring of effluent being discharged from such facilities is rarely done. Therefore, there is a need to establish the possible impact of taxidermy effluent on the environment and evaluation management options to mitigate risk.

The taxidermy that was investigated is situated in the periphery of the City of Tshwane, in an area where there is no sewer reticulation system. They draw water from a borehole on their premises, which is used at their factory to process game trophies (skulls and skins) as well as for sanitation purposes such flushing toilets and cleaning. The effluent produced from the processing of skins and skulls is currently discharged into an evaporation pond. There is a rotten egg smell emitted from the pond, which may be the source of complaints by neighboring industries. This undesirable condition of the evaporation pond led to a need to investigate and evaluate other management options for the disposal and treatment of the effluent.

The aim of this study was to identify the different processes used in order to characterize the quality of the effluent and determine the mass loads that are discharged by the taxidermy. Knowing the quality and quantity of effluent would assist in evaluating the associated environmental risks and suitability for discharge into the municipal sewer system.

2. MATERIALS AND METHODS

2.1. Taxidermy Treatment Processes

Processing of raw game trophies, according to Figure 1, involves different treatment processes. The treatment of game trophies involves washing, curing, and soaking, pre-pickling, shaving and fleshing, post-pickling for all skins. The treatment process following pre-pickling may differ depending on the skin type to be processed either mount or flat skin. For flat skins, post-pickling is followed by degreasing and chrome tanning. With mounts, post-pickling is followed by tanning without the use of chrome salts. Horns, bones and heads undergo a different form of treatment which is boiling in water at 30 ºC to remove the remaining skin and fats after shaving, followed by bleaching in a bleach solution. After bleaching, the skulls are scrubbed in a solution of soap and water. This process is known as washing [12].

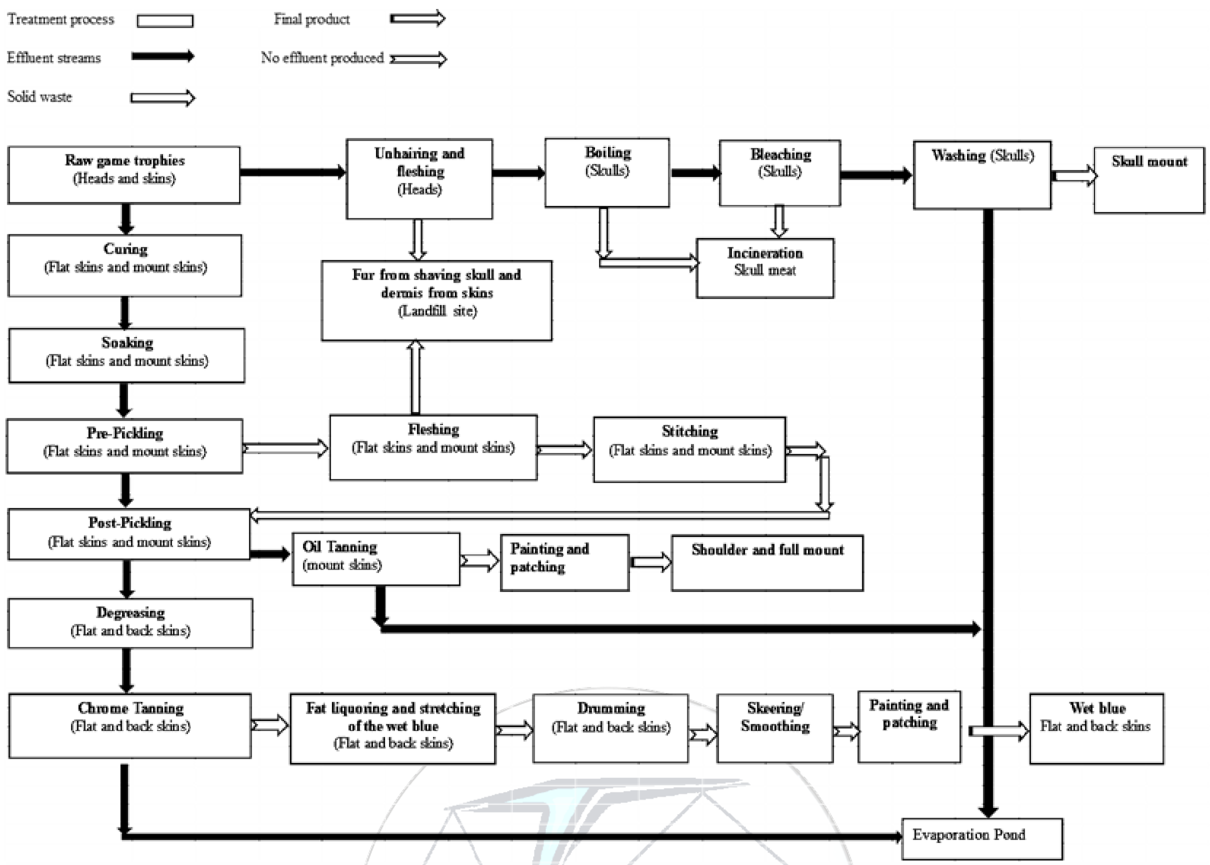

Figure 1: Flow diagram of effluent generation during treatment of game trophies (heads and skins) at a taxidermy

Table 1: Chemicals used in the Taxidermy treatment processes

Process	Chemicals
	Skins
Curing	Sodium Chloride
Soaking	Sodium Chloride washed out of cured hides and skins Detergent which was discontinued
Pre-pickling	Sodium Chloride Formic Acid
Post-pickling	Sodium Chloride Formic Acid
Oil Tanning	Sodium Chloride Eskatan GLH Liquid (synthetic fatliquor)
Degreasing	Bicarbonate of soda Gelcon PK Degreaser Conc Sodium chloride
Chrome Tanning	Aluminum Sulfate Chromosol B (chrome (III) sulfate) Eskatan GLH Liquid Lutan FN (aluminum complex salt) Sodium Chloride
	Skulls
Boiling	Sodium Chloride
Bleaching	Hydrogen peroxide (Bleach)
Washing	Detergent

2.2 Assessing the water quality of the effluent produced by the taxidermy

Effluent samples from soaking, pre-pickling, post-pickling oil tanning, degreasing, chrome tanning, boiling, bleaching and washing processes were collected weekly, bi-weekly and monthly for a period of two years

The final concentration of each parameter from the total discharge of all the processes was calculated (Equation 1) based on the mass loads discharged (Equation 2) by the different processes and the total volume.

$$\boldsymbol{Effluent\ concentration}\left(\frac{mg}{L}\right) = \frac{\boldsymbol{Average\ mass\ discarged\ per\ annum, mg}}{\boldsymbol{Average\ total\ volume\ discharge\ per\ annum, L}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The mass load was calculated as follows:

$$\boldsymbol{Average\ mass\ of\ parameter\ discharged}, \frac{mg}{annum} = C_P\ x\ V_P \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

C_P = average concentration of a parameter, mg/L, discharged from a process
V_P = average volume discharged from a process, L/annum
or expressed in kg/annum:

$$\boldsymbol{Mass\ in} \frac{kg}{annum} = \frac{mass\ in\ mg}{10^6} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

2.3 Calculation for the volume of effluent produced by the taxidermy

Processing of the skins and skulls were done in batches. The volume of effluent discharged per cycle of taxidermy treatment process was done by measuring the dimensions of each container (or bath) used in a unit process. The height of liquid that would be remaining within the bath after the treatment was then used to determine the volume to be discharged. The frequency of discharging the liquors into the evaporation dams varies from process to process. Soaking liquors are discharged after 24 hours, pre-pickling and post pickling could be discharged once in 6 months and sometimes once a year, oil tanning liquor is discharged at a similar frequency as the pickling process liquors, degreasing liquor is discharged after 24 hours and chrome tanning once in two weeks to a month.

The following calculations was used to determine the effluent discharged π x r ^{2} x h and (L x W) x h.

2.4 Sample analysis

Methods used to analyse the parameters of concern

Determination of Ammonia, Chlorides Orthophosphates and Sulphates
Standard Methods for the Examination of Water and Wastewater (APHA., 2012: 2-34, 4-110, 4-76, 4-153, 4-191)
Thermo Scientific Aquakem 250 Instrument
Determination of Chromium and Sodium
Optical Emission Spectrometer 5300 DV Instrument, Standard Methods for the Examination of Water and Wastewater (APHA., 2012: 3-69,97)
Determination of Chemical oxygen demand
Open Reflux Method (APHA., 2012: 5-20)
Determination of Electrical Conductivity and Ph
Measured onsite with a multi meter Hatch HQ40d
Determination of Fats and Oils
Partition-Gravimetric Method (APHA., 2012:5-45)

3. RESULTS AND DISCUSSIONS

3.1 Volume of water used by the taxidermy

The volume of water used annually was calculated based on the dimensions and frequency of effluent discharge from each batch (Table 4). For the period (May 2016 - April 2018) the taxidermy processed 2 248 skins and 1 125 skulls as shown in Figure 2.

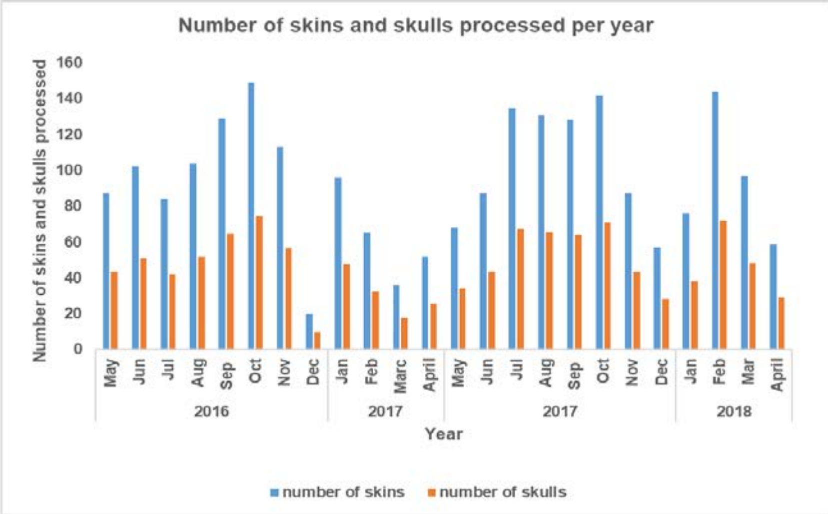

Figure 2: Number of skins and skulls processed between May 2016 and April 2018

The volume of effluent discharged into the evaporation pond was determined by the number of skins and skulls produced during the effluent monitoring period. Each process generated the following volume of effluent annually: soaking 1. 75±0.27 m^3, pre-pickling 1.16±0.001 m^3, post-pickling 1.02±0.001 m^3, oil tanning 1.12±0.001 m^3, degreasing 1.10±0.12 m^3, chrome tanning 4.72±0.37 m^3, boiling 16.86±1.85 m^3, bleaching 3.15±1.06 m^3 and washing 2.86±0.31 m^3 (Table 2).

Table 2: Volume of effluent produced per annum at the taxidermy

Process	Number of skins produced per annum	Effluent produced per annum (m^3)
	Skins	
Soaking	1 124±123	1. 75±0.27
Pre-pickling	1 124±123	1.16±0.001
Post-pickling	1 124±123	1.02±0.001
Oil Tanning	337±37	1.12±0.001
Degreasing	787±86	1.10±0.12
Chrome Tanning	787±86	4.72±0.37
Total for skins	**1124±123**	**10.87±0.76**
	Skulls	
Boiling	562±62	16.86±1.85
Bleaching	562±62	3.15±1.06
Washing	562±62	2.86±0.31
Total for skulls	**562±62**	**22.87±3.22**
Total for Taxidermy	**1989±183**	**33.74±3.98**

3.2 Assessing the water quality in each production process

Figures 3 – 8 shows the average mass load of the parameters assessed in the effluents from the various skin/skull treatment processes during the sampling period. While Figure 9 – 10 show the average concentration of the pH and electrical conductivity measured during the sampling period.

Chemical oxygen demand (COD)

Chemical oxygen demand is defined as the oxygen required to breakdown complex organic compounds into simple intermediate compounds [1]. The average chemical oxygen demand concentration of the taxidermy treatment processes which were above 5 000 mg O_2/L were as follows, pre-pickling 15 028±3 742.12 mg O_2/L, post pickling

16 720.91±4 072.83 mg O_2/L, oil tanning 23 863.21±10 610.51 mg O_2/L, degreasing 23 272.38±7 937.81 mg O_2/L, chrome tanning 21 799.40±10 071.66 mg O_2/L, boiling 8 479.16±3 432.09 mg O_2/L, bleaching 6 307.42±5 707.74 mg O_2/L and washing 5 974±3 124.07 mg O_2/L. The calculated COD concentration in the effluent would be 11 035.60 mg O_2/L with a mass load of 372.34 kg O_2/a. The highest COD mass loads in Figure 3 were from, the Boiling (142.96 ± 57.87kg O_2/a), Chrome Tanning (102.91 ± 47.55 kg O_2/a), and processes.

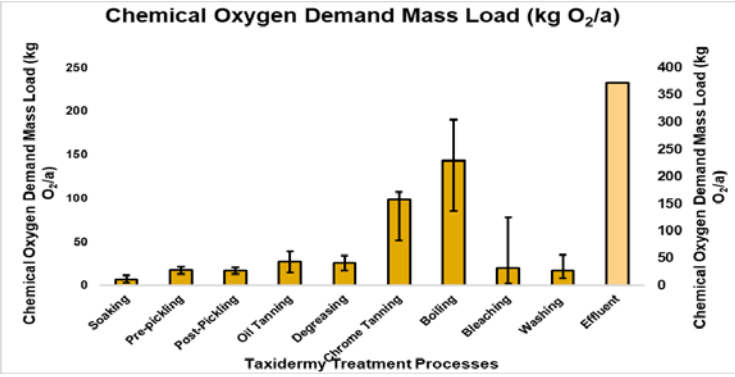

Figure 3: Chemical oxygen demand mass load, kg O2/a, for the skin/skull treatment process

The high concentrations were due to the chemicals added as well as the physical properties of the skins and skulls.The high COD was mainly due to the skulls as they were boiled with some fat attached to them. The oils and fats originated from processing of skulls and skins.

The skins were soaked in Eskatan GLH solution during chrome and oil tanning processes. Eskatan GLH is known as a synthetic fatliquor or tanning oil ([20],[7]). The COD in the pre and post pickling process was mostly caused by the use of formic acid, which is used to preserve the skins and to prepare them for the tanning processes [3]. The degreasing solution contains organic solvents or surfactants (Gelcon PK Degreaser) which composed of non-ionic tensides and hexylene glycol. The function of a degreaser is to remove fats and oils from the skins. Because of the degreasing of the skins, the liquors from this process will contain a high chemical oxygen demand concentration [5].

Nitrogen compounds (Ammonia and Nitrate/Nitrite)

Nitrogen within tanning effluents exists as ammonia and nitrate/nitrite emanating from protein material found in hides [18].

Ammonia

The soaking process had the highest ammonia concentration and mass load, at 74.73 ±28.29 mg N/L and 0.13±0.05 kg N/a, respectively, whereas the other treatment processes had concentrations of less than 1 mg N/L. The calculated final ammonia concentration was 3.95 mg N/L with a total mass load of 0.13 kg N/a.

The high ammonia concentrations in the soaking process (74.73±28.29 mg N/L) could be due to traces of urine, dung and soluble proteins on the game trophy skins. Reference [8] revealed in their study that ammonia is caused by urine on the hides/skins in the effluent of soaking process

Nitrate/Nitrite

The nitrate/nitrite concentration during soaking, pre-pickling, post-pickling, oil tanning, degreasing, chrome tanning, boiling, bleaching and washing was found to be less than 1 mg N/L. The calculated final nitrate/nitrite concentration was 0.15 mg N/L with a mass load of 0.01 kg N/a.

Ortho-phosphate

Ortho-phosphate is most commonly found in detergents, which are widely used in taxidermy effluent treatment processes. As shown in Figure 4, orthophosphate mass loads were all less than 1 kg P/a while the ortho-phosphate concentration for the skin treatment processes which was above 8 mg P/L were: soaking 18.64±5.63 mg P/L, pre-pickling 17.61±1.28 mg P/L, post-pickling 29.23±25.87 mg P/L, for skins, while for skulls it was from the boiling 15.18±5.82 mg P/L. With a mass load of 0.35 kg P/a, the calculated orthophosphate concentration in the effluent was found to be 10.28 mg P/L.

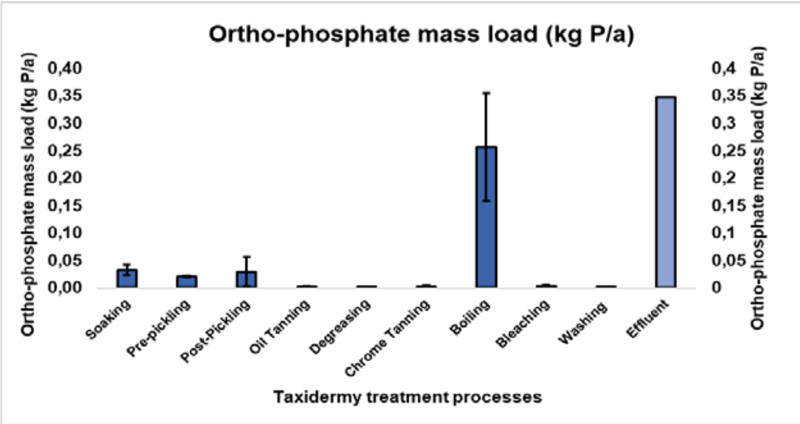

Figure 4: Ortho-phosphate mass load in (kg P/a) for the skins/skull's treatment processes

Soaking and the two pickling processes were the major contributors of ortho-phosphate (from the detergents) to the taxidermy effluent. When the remaining flesh, fats, and oil from the skulls were removed by boiling them in water, a broth was formed. Because bones contain high concentrations of phosphate, this broth contained high phosphate. This was showed in an experiment conducted by Dalby to determine the mineral content of two bones, which yielded the following phosphorus results: 8.9 mg / 240 mL and 12.5 mg / 240 mL [14].

Chloride

The chloride in the tanning process liquors yielded the following results for skin treatment: soaking 16 799.33±1 971.62 mg Cl^-/L, pre-pickling 20 694.31±2 282.51 mg Cl^-/L, post pickling 20 733.91±2 409.61 mg Cl^-/L, degreasing 16 171.03± 1 595.79 mg Cl^-/L, oil tanning 18 938.72±2 181.49mg Cl^-/L, chrome tanning 16 073.00 ± 5 342.62 mg Cl-/L, while the concentrations for boiling in skull treatment was 1 313.87±566.43 mg Cl^-/L, bleaching 295.39±488.90 mg Cl^-/L and washing 76±27.61 mg Cl^-/L which were all above the discharge limit of 69 mg Cl^-/L for chloride. With a mass load of 209.92 kg Cl^-/a, the calculated chloride concentration in the effluent was 6 222.46 mg Cl^-/L. Figure 5 shows that the highest chloride mass load was 73.14 kg Cl^-/a, which was achieved through Chrome tanning.

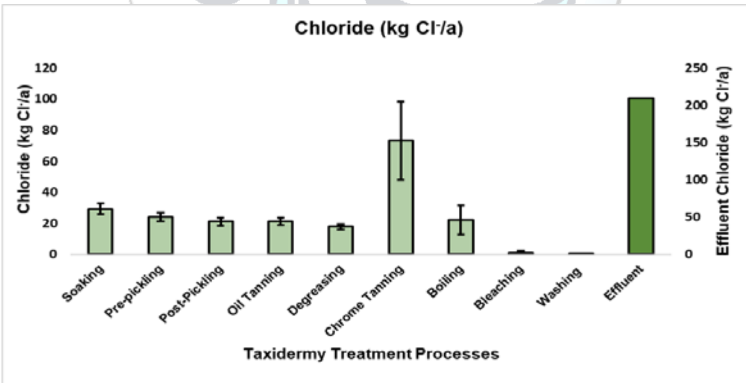

Figure 5: Chloride mass load in, kg Cl^-/a, for the skins/skull's treatment processes

The use of sodium chloride throughout the taxidermy treatment processes has resulted in the high chloride concentration in the final effluent. The high chloride in effluent is of concern because it is not removed during biological wastewater treatment processes, resulting in high chloride concentration in the effluent discharged into the receiving water bodies [1]. High chloride has a negative impact on the receiving water bodies as it inhibits the growth of plants, bacteria and fish due to cell structure breakdown. Water containing high chloride concentrations cannot be used for irrigation since surface salinity will increase due to evaporation, resulting in a decrease in crop yields [19].

Sodium

The sodium analysis results for the treatment processes which were above the limit of 300 mg Na^+/L were: soaking 15 125.97±3 442 mg Na^+/L, pre-pickling 27 279.79±4 774.97 mg Na^+/L, post-prickling 28 737.55±4 462.02 mg

Na^+/L, oil tanning 21 916±2 737.75 mg Na^+/L, degreasing 24 492.65±4 186.35 mg Na^+/L, chrome tanning 22 711.49±4 466.81 mg Na^+/L and boiling 1 043.25±592.57 mg Na^+/L. The calculated sodium concentration in the effluent was 7 834.91 mg Na^+/L with a mass load of 264.35 kg Na^+ /a. Figure 6 shows the highest sodium mass load of 107.22 kg Na^+ /a, which was achieved through Chrome tanning.

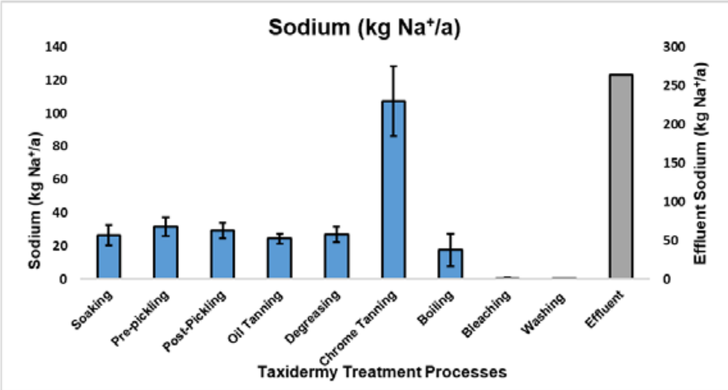

Figure 6 Sodium mass loads, kg Na^+ /a, for the skins/skulls treatment processes

Sodium chloride is widely used in the taxidermy treatment processes, resulting in an increase in the total sodium concentration in the final taxidermy effluent.

Sulfates

The sulfate analysis results obtained above 1 800 mg SO_4^{2-}/L for treatment processes were as follows: pre-pickling 2 370.23±780.76 mg SO_4^{2-}/L, post pickling 2 179.45±1 529.06 mg SO_4^{2-}/L, oil tanning 3 812.67±292.58 mg SO_4^{2-}/L, degreasing 1 978.37±1 587.01 mg SO_4^{2-}/L chrome tanning 7 592.52±2 060.39 mg SO_4^{2-}/L. The sulfates concentration in the effluent was calculated to be 1 580 mg SO_4^{2-}/L. From Figure 7, the highest sulfates mass load was 35.84±9.72 kg SO_4^{2-}/a achieved from chrome tanning. The calculated sulfates mass load was 53.44 kg SO_4^{2-}/a.

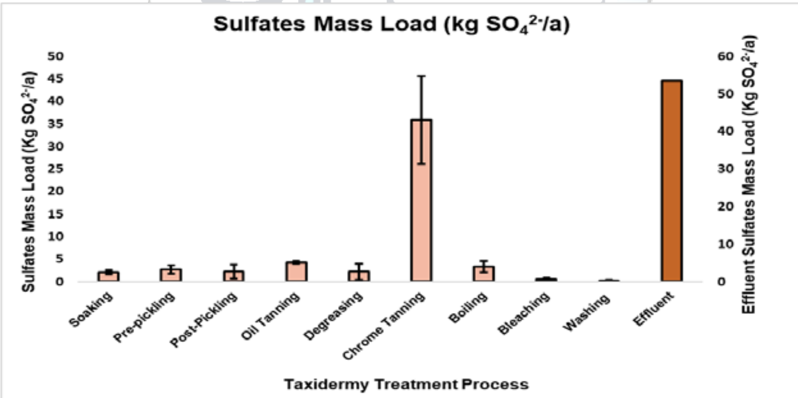

Figure 7: Sulfates mass loads, kg SO_4^{2-}/a, for the skins/skull's treatment processes

The presence of sulfates in tanning effluents is due to the use of chrome (III) sulfate as a tanning agent during chrome tanning [18]. Both these ion salts are problematic for treatment of effluents which contain them. The conversion of sulfates to hydrogen sulfide can result in the corrosion of metal components of the sewer line conveying the effluent containing hydrogen sulfide, as well as erosion of the sulfate resistant concrete sewer system

Total Chromium

Pre-pickling (18.5±2.08 mg Cr/L), degreasing (2.63±1.26 mg Cr/L) and chrome tanning (3 352.55±750.22 mg Cr/L) were the only treatment processes that contained chromium. With a mass load of 15.85 kg Cr/a, the calculated concentration was 469.78 mg Cr/L.

The use of chrome (III) sulfate has contributed to the presence of the high concentration of chrome (III) in the final effluent. Chrome (III) is highly stable and easily adsorbed onto soil particles when the pH is less than 4, whereas chrome (VI) is simply mobilized in acidic and alkaline soils [17]. In soils that are alkaline, chrome (III) will not be absorbed and can pollute groundwater. Chlorination of water containing chrome (III) can cause the oxidation of chrome (III) to results into the more toxic chrome (VI) in areas where groundwater is the primary water source [10].

Total Fats and Oils

Fats and oils were detected in the following processes: oil tanning 10 528±4 434.51 mg/L, chrome 3 962±1 576.89 mg/L, boiling 1 788.13±570.11 mg/L and bleaching 1 157.53±1 170 mg/L. Mass load and effluent concentration were 55.19 kg/a and 1 635.79 mg/L, respectively. The highest mass load in Figure 3.8b was from the boiling ca 18.70 kg/a.

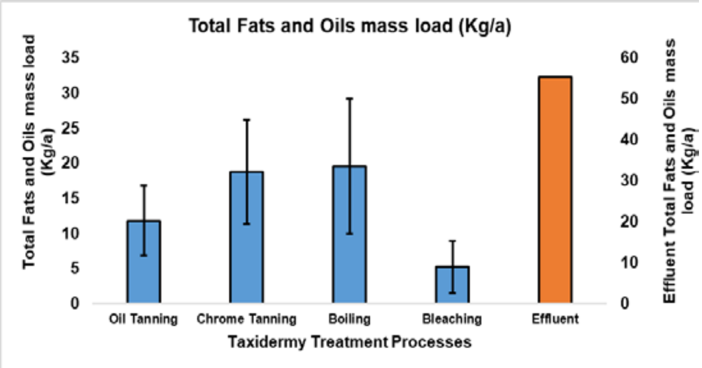

Figure 8: Total Fats and Oils in kg/a, for the skins/skull's treatment processes

During the tanning process, natural oils and grease are released from within the skin structure [8]. Some fatty substances maybe produced through inter-reaction when effluents are mixed. While some processes such as oil tanning and chrome tanning make use of synthetic fatliqours these also contribute towards the fats and oils in the final effluent.

pH

The pH values ranged between pH 3.2 and 7.9 (Figure 3.9). The pH values for each process were as follows: soaking 7.12±0.36, degreasing 7.17±0.43, pre pickling 3.18±0.12, post pickling 3.14±0.31, oil tanning 3.4±0.18, chrome tanning 3.19±0.28, boiling 7.00±0.51, bleaching 7.59±0.5 and washing7.92±0.43.

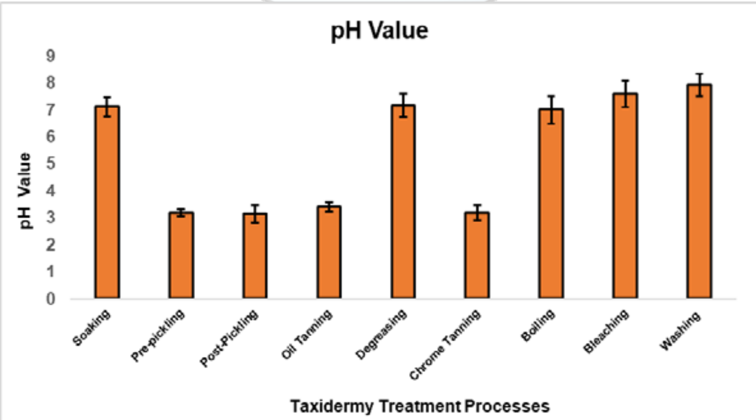

Figure 9: pH for the skins/skull's treatment processes

The pH values for each process differed due to the use of acids, bases and other chemicals, which impacted the pH values of the treatment processes. Soaking is used to rehydrate the skin to prepare for tanning, while formic acid is used to preserve the skins and prevent degradation. Chrome salts, such as chromium (III) sulfate, are best absorbed into the skins in acidic conditions. To achieve neutral pH values, chemicals which may affect the pH of the skin are not added during soaking [8]. Acidic liquors were present in the following processes: pre-pickling pH 3.18±0.12, post-pickling pH 3.14±0.31, oil tanning pH 3.4±0.18, and chrome tanning pH 3.19±0.28, while the other processes had near neutral pH values.

Electrical conductivity

The electrical conductivity measured for the soaking process was 5 631.16±1 243.93 mS/m, pre-pickling 9 678±1 602.48 mS/m, post pickling 9 741.55±1 478.01 mS/m, oil tanning 7 320±1 035.06 mS/m, degreasing 7 667.59±1 177.73 mS/m, chrome tanning 7 240.50±891.72 mS/m, boiling 835.72±343.12 mS/m, bleaching 154.17±45.98 mS/m and washing 120±27.11 mS/m.

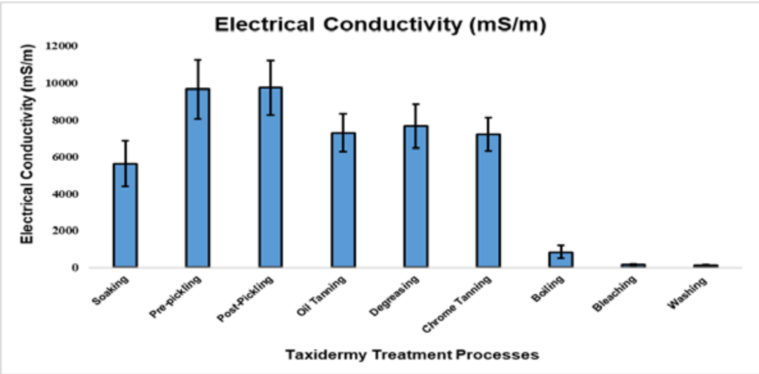

Figure 10: Electrical conductivity in mS/m for the skins/skull's treatment processes

Borehole water is used to make solutions which are used in taxidermy treatment processes. The electrical conductivity in the treatment process was increased due to the use of sodium chloride and other salts when preparing the treatment solutions [8].

Table 3: Calculated final effluent concentrations discharged from the taxidermy

Parameter	Calculated effluent concentrations discharged by the taxidermy (mg/L)	Limits set by City of Tshwane (mg/L)	Mass load discharged by the taxidermy (kg/a)
Ammonia (mg N/L)	4	25	0.13
Chemical Oxygen Demand (mg O_2/L)	11 035.6	600 – 5 000	372.34
Chloride (mg Cl^-/L)	6 221.62	69*	209.92
Chrome (Total), Cr^{3+}) (mg Cr/L)	469.86	20	15.85
Ortho-phosphate (mg P/L)	10.28	10	0.35
Fats and Oils (mg/L)	1 635.79	500 – 2 000	55.19
Sulfates (mg SO_4^{2-}/L)	1 580	1 800	53.44
Sodium (mg Na^+/L)	7 835.95	300	264.35

* Chloride limit determined by designated wastewater treatment works inflow chloride concentration.

All parameters have relatively low mass loads (Table 3) and will be diluted if treated in a large wastewater treatment plant, which treats 85 ML/d. However, permission to discharge the effluent into the municipal sewer line still remains the prerogative of the municipality while taking into consideration the long-term impact of such effluents.

The concentration of ammonia was within the City of Tshwane's permissible limits of 25 mg N/L [9] for effluent discharge from the taxidermy, whereas the other parameters such chemical oxygen demand with a concentration of 11 035.60 mg O_2/L, Chrome (Cr^{3+}) with 469.86 mg Cr/L, Chloride with 6 221.62 mg Cl^-/L and Sodium with 7 834.91 mg Na^+/L were not within the permissible limits for discharge into the sewer line as shown in Table 3.

The COD in the taxidermy effluent was found to be quite high (approximately 11 000 mg O_2/L), some of the chemical compounds used in taxidermy are known to be unbiodegradable. Particularly synthetic fat liquoring compounds, such as Eskatan GLH, are known to have low biodegradability [16], reducing the efficiency of biological treatment processes.

Because of the high COD concentration in the effluent, it may be possible to treat it using a biological process. However, due to the relatively small volumes of wastewater generated in taxidermy, treatment in an on-site system would be possible. On-site treatment systems have low capital expenditures for new infrastructure and low operational costs for maintenance [21]. Consequently, septic tanks with French drains and fenced-off treatment ponds are the most often used on-site treatment systems in South Africa currently.

4. CONCLUSIONS

The taxidermy investigated was a medium sized facility which produced less than 2 000 trophies per annum, and discharged an estimated effluent of 33.7 m^3/a. Several of the treatment processes in the taxidermy produced highly polluted effluents, which could pose serious risks for groundwater pollution. The effluent contained high concentrations of COD with a concentration of 11 035.60 mg O_2/L, Chrome (Total), (in the form of Cr^{3+}) at 469.86 mg Cr/L, Chloride at 6 222 mg CL^-/L, Ortho-phosphates at 10.28 mg P/L, Fats and oils at 1 635.79 mg/L and Sodium at 7 835 mg Na^+/L.

It is recommended that these pollutants are removed before discharge into the environment or an alternative would be applying for permission to discharge into a municipal sewer and complying with municipal discharge regulations.

Further studies should be done to determine the most efficient and cost-effective method for discharge.

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6. CONFLICT OF INTEREST STATEMENT

The author(s) declare(s) that there is no conflict of interest.

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