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Determination of levels of heavy metals and physicochemical parameters in waste water of Kasuwan shanu abattoir, Maiduguri

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ABSTRACT

Kasuwan shanu is the central abattoir located in the city of Maiduguri, the Borno state capital, in Northeastern Nigeria. Sample of waste water from this abattoir was collected for determination of levels of some heavy metals (Cd, Fe, Mn, Hg, Zn, Ni, Cr) and physicochemical properties. The sample was analyzed according to standard procedures. The results of the study revealed the order of the concentrations of the studied heavy metals as Ni > Zn > Mn = Hg > Cd > Fe > Cr. The levels of the heavy metals were above the permissible limits set by the World Health Organization (WHO) except Fe, Mn and Zn which fall within acceptable limits. The physicochemical parameters were also within the permissible limits except turbidity and electrical conductivity values which stood at 34 Formazin Turbidity Unit (FTU) and 1784 µS/cm respectively, against the 5 and 1000 µS/cm standard limits for their discharge.

1. Introduction

Contamination of river bodies from abattoir waste could constitute a significant environmental and health hazards [1,2]. The location of abattoirs is generally unregulated, aside, they are usually located near water bodies where access to water for processing is guaranteed. The animal blood is released untreated into the flowing stream while the consumable parts of slaughtered animals are washed directly into the flowing water. Improper management and supervision of abattoir activities have been identified as a major source of public health in south western Nigeria [3,4]. Waste from slaughter houses typically contain fat, grease, hair, feathers, flesh, manure, grit and undigested food, blood, bones and processing water which is characterized by high organic level [5,6].

The total amount of water produced by animal slaughter is approximately 35 % its weight [7]. In earlier study, it was found out that, for every 1000 kg of carcass weight, a slaughtered beef produces 5.5 kg of manure and 100 kg of paunch manure (partially digested food) [8]. The weight of matured cow varies with size, ranging from 400 kg for thin, 55 kg for moderate to 750 kg for extremely fat. A more detailed statistics on the weights of both life and dead cows was reported in the literature [9]. A cow weighing 400 kg would have its carcass weight reduced to about 200 kg after slaughter. Furthermore, it loses about one third fat and bone after passing through the butchery process. Hence a live animal with a body weight of 400 kg will give 140 kg of edible meat which represents only 35% of its weight. The remaining 65% are either solid or liquid waste. Improper management of abattoir wastes and subsequent disposal either directly or indirectly into the river bodies portends serious environmental and health hazards both to aquatic life and humans. In all the urban and rural towns in Nigeria, the abattoir waste originates from killing, hide removal or dehairing, paunch handling, rendering, trimming, processing and clean-up operations in the abattoir. Fresh abattoir waste water is mainly composed of diluted blood, fats and suspended solids [26].

Kasuwan shanu abattoir is located in Maiduguri metropolis, Borno State, Nigeria. Animals (cow, goats, cattle, camels) are slaughtered daily throughout the year. The waste water generated flows directly into river without treatments. This river is also used for irrigation of vegetables along the river bank. The activities of this abattoir remain unregulated. Therefore, it is necessary to initiate preliminary research to investigate the quality of abattoir waste water from Kasuwan shanu abattoir situated in Maiduguri, the Borno state capital in Nigeria;

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before discharging to the bare earth as being practiced.

2. Results and Discussion

2.1 Physicochemical properties

The results of the physicochemical parameters are presented in Table 1.

Table 1: Result of the Physicochemical parameters in comparison with WHO standard

Parameters	Units	Values Observed	WHO Standard[11]
pH	-	5.661	6.5-8.5
Turbidity	FTU	34	5
Total Dissolve solids (TDS)	mg/l	260	500
Electrical Conductivity (EC)	µS/cm	1784	1000
Temperature	^{o}C	26.4	< 40

The mean concentrations of the heavy metals in the abattoir waste water alongside WHO standards are presented in Table 2.

Table 2: Heavy metal mean concentrations in the abattoir waste water sample (mg/l)

Parameters	Concentration (mg/l)	WHO Standard
Cd	0.12667	0.01
Fe	0.1100	0.31
Mn	0.13333	5.00
Hg	0.13333	0.00
Zn	0.18000	3.00
Ni	1.54333	0.02
Cr	0.10333	0.05

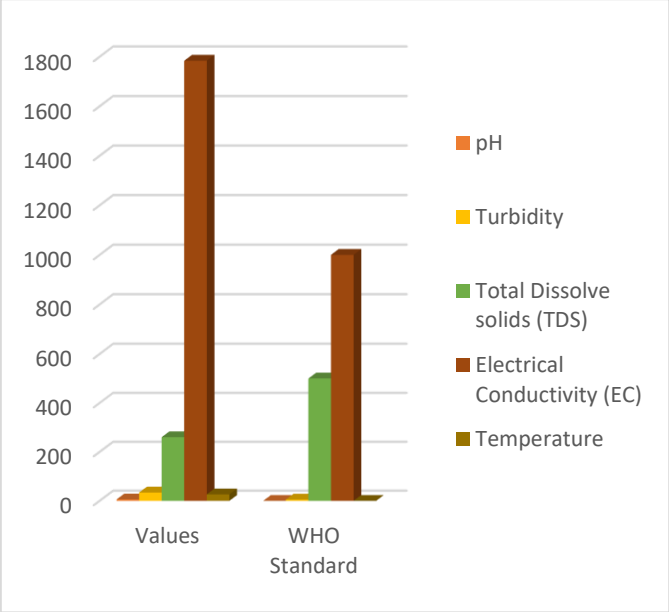

Fig. 1: Comparison of physicochemical parameters with WHO standard

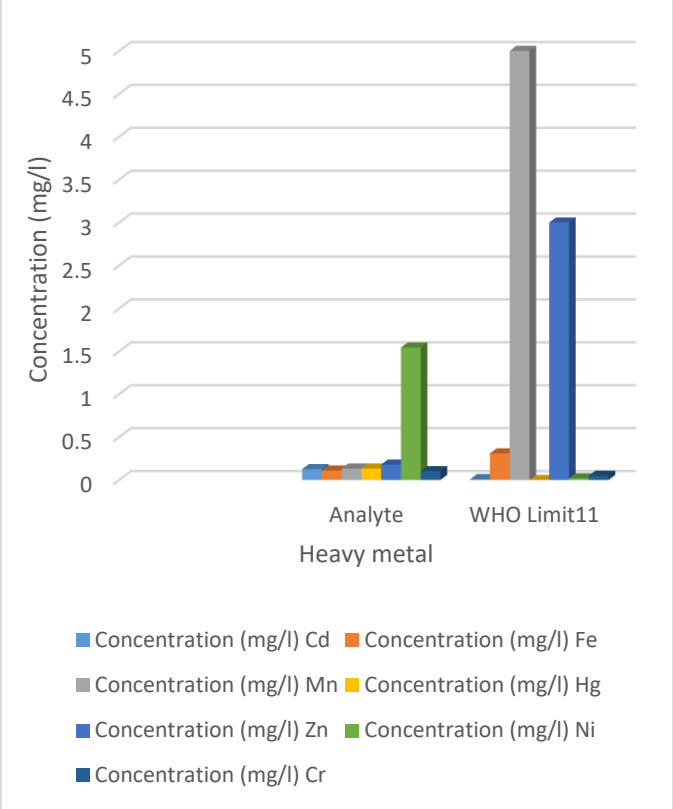

Fig. 2: Comparison of heavy metal mean concentrations with WHO standard

pH

The observed pH value of 5.661 is indicative of its acidity [12]. Although the value is in concordance with earlier report [13] and within the allowable limit of the WHO, it may likely cause undesirable ailments such as acidosis. The acidic nature could be attributed to the type of waste which include dung, blood, fat, intestines and urine which

are generated from the abattoir which reduced anaerobic activities [14].

Turbidity

The turbidity value of 34 recorded in the study is lower than 115 as earlier reported [15] and higher than the 2 reported in another study [13].

Total dissolved Solids (TDS)

The measured TDS value of 260 mg/l falls within the acceptable limit [11]. The implication of high value of TDS among others is that the water can corrode containers used for water storage [13].

Electrical conductivity (EC)

Conductivity measures the amount of dissolved salts present in water. However, it does not indicate the type of ions present [16]. The electrical conductance value was measured as 1784 µs/cm. The value is higher than the WHO limit of 1000 µs/cm. This high EC could be imputed to the collation of wastes such as bones, hairs, flesh and blood discharged into abattoir waste [17]. The values obtained are higher than the values earlier reported in similar studies [14,17].

Temperature

Temperature is one of the most significant environmental parameters in effluent as is responsible for behavioral characteristics of organisms, solubility of gases and salts in water [18]. Although the observed temperature of 26.4 ^{o}C recorded in this study is within the permissible limit of < 40 set by WHO [11], but lower than the range of 27.8-29.1 ^{o}C reported in the literature [19]. The parameter is of great importance as it affects the amount of total dissolved oxygen which in turn affects survival of microorganisms.

2.2 Heavy metals analysis

The mean concentrations of heavy metals in the abattoir water alongside WHO standards are presented in Table 2. Heavy and trace metals are of importance in water as living organisms require varying amounts of some of these metals as nutrients for proper growth and development; e.g. Cu, Fe, Mn, Ni and Zn. On the other hand, metals such as Ag, Cd, Pb, and Hg have no any biological role and hence are non-essential [20]. Their presence in waste water is due to discharge from residential dwellings groundwater infiltration and industrial discharges[12]. The concentration levels of heavy metals in most Nigerian rivers is well above the acceptable and allowable limits: Pb, Cu, Zn, Ni, Cr, Cd and Fe [21].

Cd

The detected concentration of Cd was 0.12667 mg/l, greater than the WHO permissible level of 0.01 mg/l. Cadmium can cause kidney lesions, hypertension, mutagenesis and carcinogenesis. The most important adverse effect of cadmium in human is Itai-Itai disease which affects calcium and bone metabolism and was first reported in Japan as it was consumed through contaminated rice [22].

Fe

The concentration of iron stood at 0.11 mg/l. Though the value is below the reported concentrations of 0.54 mg/l in earlier reported work [19], but is within the allowable limit set by WHO [11]. The presence of iron in the abattoir waste could be ascribed to the deposit of blood leached into the water.

Mn

Manganese is an essential element for humans and plants, but high concentrations in drinking water when consumed can result to adverse neurological disorders. In the present study, it has a concentration of 0.13333 mg/l which is within the permissible limit of 5 mg/l as set by WHO [11].

Hg

The concentration of mercury in the sample stood at 0.13333 mg/l which is higher than the WHO permissible limit. Mercury is considered by WHO as one of the top ten chemicals or group of chemicals of major public health concern. Exposure to mercury – even small amounts - may cause serious health problems and is a threat to the development of the child in the utero and early in life. It may have toxic effects on the nervous, digestive and immune systems, and on lungs, kidneys, skin and eyes [23].

Zn

The observed level of zinc was 0.18 mg/l. The value falls within the allowable limit of 3.0 mg/l. Accumulation of zinc may be from infiltration of rainwater from roofs in the area [13]. Zinc deficiency or excessively high levels may enhance susceptibility to carcinogenesis [24].

Ni

The concentration of nickel was detected as 1.54333 mg/l. The value is higher than the WHO permissible limit of 0.02 mg/l; and that reported earlier in the literature [13]. Nickel is a well-known carcinogen to humans, by altering the DNA functions [25].

Cr

The value obtained is above the WHO acceptable limit of 0.05 mg/l. The pollution of the analyte by chromium could be related to improperly thrown wastes from chromate-processing amenities within the vicinity. The water-insoluble hexavalent chromium is more harmful with effects such as liver necrosis and membrane ulcer; and dermatitis when it has contact with the skin [13].

3. Materials and methods

3.1 Materials

All chemicals used were of analytical grade and freshly distilled water was used throughout the experiments. Wagtech physicochemical testing kit CP 1000 Wagt-WE 107206 and smart calorimeter model smart3 26866 were used for physicochemical analysis.
The heavy metals were determined using AAS BUCK scientific (model 210 VGP). An air/acetylene flame was used for the determination of the metal ions with an average time of 30 seconds.

3.2 Study area
Maiduguri central abattoir is located along Kasuwan shanu road in Maiduguri, Borno State, Northeastern Nigeria.
The slaughter house is divided into different sections viz, the butchering section, where the animals are rendered; the rinsing section where animals' parts are rinsed; and dung pit where intestines are emptied. About 30 cows, 40 rams, and 60 goats are slaughtered daily in the abattoir. The wastes from the abattoir are collectively discharged into an open land directly behind the abattoir without treatment.

3.3 Sampling
Abattoir waste water sample were collected in Plastic containers which were earlier cleaned by washing with detergent, rinsed with distilled water soaked in 10% HNO_3 for 24 hours and finally rinsed with deionized water prior to usage. During sampling, Sample bottles were rinsed four times with the sample and filled to capacity. Sampling was carried out in the morning period at the peak of the slaughter house activities between the hours of 8:00 am and 9:00 am using 500 ml sterilized Pyrex glass bottle with light screw stoppers. Waste water samples were collected at the abattoir from a point where it was thoroughly mixed and closed to the discharging point below the surface. The samples for metal analysis were preserved in concentrated nitric acid (1 ml acid per liter of sample) labeled and transported to the laboratory for analysis.

3.4 Determination of physicochemical properties
The temperature, pH, turbidity, conductivity and total dissolved solids of the waste water were measured directly using waste physicochemical testing kit CP 1000 Wagt-WE 107206. The methodologies used were based on the manufacturer's instrument manuals for each of the components in the kit.
The pH meter measures within the range of -10 to 15 with a resolution of 0.01 and accuracy of ±0.01.
The conductivity /total dissolved solids meter has a range of 0 to 2000 µS/cm, with resolution of 1 µS/cm and accuracy of ±1 % full scale. It measures temperature within the range of 0 to 50 ^oC with resolution of ±0.1 ^oC and accuracy of ±0.5 ^oC.

3.5 Determination of heavy metals
3.5.1 Digestion of sample
The sample was digested by adding 5 ml of concentrated HNO_3 to 100 ml of samples in a beaker and heated for about 20 mins. The process was repeated until a virtually clear solution is obtained. The beaker wall and watch glass were washed into it using distilled water and the sample was filtered to remove some insoluble materials that could clog the atomizer. The volume of the sample was adjusted to 100 ml with distilled water. A blank sample was digested so as to allow a blank correction to be made. This was done by transferring 100 ml into a beaker and digested as described above. Determination of heavy metals was made directly on each of the final solution using atomic absorption spectrophotometer [10].

4. Conclusion

The present work reports some physicochemical properties and levels of some heavy metals in waste water from Kasuwan Shanu abattoir. The mean concentrations of the studied heavy metals follow the sequence Ni > Zn > Mn = Hg > Cd > Fe > Cr. The levels of Fe, Mn and Zn fall within the allowable limits set by WHO, whereas Cd, Hg, Ni and Cr exceeded the permissible limits which is ascribable to the improper waste disposals among other factors. The determined physical parameters also fall within the limits allowed. However, turbidity and conductivity were found above the acceptable limits for abattoir waste water. This study indicates that the waste water from Kasuwan Shanu abattoir may likely pose health risk or hazard over a longtime exposure.

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