



Original Paper

Determination of Lead and Cadmium level in cattle offals, water and feed in Omdurman locality –Sudan

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Abstract-- This study was carried out to determine the level of Cadmium (Cd) and Lead (Pb) in cattle meat, offals, water and feed samples. The samples were obtained from Al Muwalih area (Omdurman locality- Sudan). Laboratory analysis was carried out using Atomic Absorption Spectroscopy. Usually, animals are transported from the Western region of Sudan to the capital city Khartoum, where after few months they will be slaughtered for consumption. The highest concentration of Cd and Pb was observed in kidney and liver with a mean of 0.0302 ± 0.003 mg/g and 0.259 ± 0.008 mg/g respectively. High levels of Cd and Pb were also detected in water and feed samples. It is thus important to supply safe feed for animals to safeguard animal health and reduce the risk of exposure of consumers to heavy metals.

Keywords-- Heavy metals, Meat, cattle, Food analysis, Sudan

I. INTRODUCTION

Heavy metals in food is becoming one of the major current health problems especially because of their ability to be transferred through the food chain. Thus, food contamination with heavy metals, especially lead (Pb), cadmium (Cd) and mercury (Hg), that are not usually metabolized by the body can have toxic effects due to their bio accumulation within the body tissues. [1-2]

Meat is a rich and convenient source of nutrients such as proteins and other micronutrients [3-4]. Offal are the eatable parts of an animal and is very popular in the Middle Eastern countries due to its unique flavor, texture, aroma, in addition to high content of vitamins, and minerals like phosphorus, iron, copper, magnesium, iodine, calcium, potassium, sodium, selenium, zinc and manganese needed by the human body [5-6-7].

Several factors may affect the concentration of heavy metals in animal tissues or products such as animal species, the breeding system, the type of feed, slaughter and transportation conditions, seasonality and free grazing [8, 59]. In addition to pollution of water, or environment, use of animal drugs, pesticides, and other agricultural or industrial chemicals may also affect the level of heavy metals in the tissues [9-10-11].

Cd and Pb are known to be highly toxic heavy metals [12, 57]. Chronic exposure to Cd can lead to damage in the kidneys, liver, various body systems such as immune, reproductive, cardiovascular, nervous and gastrointestinal track [13]. Bone demineralization is also affected by Cd toxicity directly and indirectly as a result of renal dysfunction [14]. Pb toxicity can lead to reproductive dysfunctions, nephropathies, damage to the central as well as the peripheral nervous system and interference with the body enzymatic systems [15]. It can also cause carcinogenesis, mutagenesis and teratogenesis [16]. In Sudan, cattle are mainly grazed in the natural pasture during the rainy seasons then transported to big cities, kept for some time until slaughtering. During this period, animals may be exposed to various sources of metal contamination originating from water used for drinking, the roughage used for feeding or from the environment.

This study is among the first studies carried out locally to measure the level of Cd and Pb in cattle meat and offal. The study also aims to compare the level of these metals with the International acceptable limits and determine the possible sources of contamination.

II. MATERIALS AND METHODS

A. Study Area

In the current study samples were obtained from Omdurman locality which has one of the largest cattle markets (Al - Muwalih) for receiving livestock from all parts of the Sudan. The animals are usually kept for some time till slaughter. The area also contains a large number of slaughter houses which are the main source for providing meat for local consumption.

B. Data Collection

The data was obtained in two parts:

- (i) Questionnaire: a pre structured questionnaire was filled out to obtain data regarding the origin of the animal, age, type of feed, source of water.

(ii) Sample collection: a total of 30 fresh samples (10 muscle, 10 liver and 10 kidney) were collected randomly immediately after slaughtering. The samples were collected in clean bags and sent to the laboratory for analysis (Veterinary Research Laboratory—Soba). In addition 10 samples of feed and water were collected from the rearing area (Omdurman locality).

C. Laboratory Analysis

The level of Cd and Pb were measured using Atomic Absorption Spectrophotometer method [12].

Sample preparation:

- (i) Muscle and Feed : two gms of muscle samples or feed were placed in a crucible then dried at 550 – 600 OC for three hours. Followed by the addition of 10 mL HCl 50% and 5 mL 33% HNO₃ (Acid digestion technique) , heated at 100 OC for one hour. Then the samples were filtered and the volume was completed to 100 mL using distilled water.
- (ii) Liver and kidney : five gms of liver or kidney were digested in 20 ml concentrated nitric acid HON₃ for 24 hours at room temperature .Then the samples were filtered and the volume was completed to 50 mL using distilled water then transferred into a plastic container for analyses.
- (iii) Water: 50 mL of the water samples were weighed into a flask and 1 mL of 1% HCl was added.

D. Element Analysis of Samples

Standard solutions of the respective metals were used to establish standard curves before metal analysis. Concentrations of Cd and Pb were determined directly using Atomic Absorption Spectroscopy.

E. Statistical Analysis

Data was analyzed using SPSS version 20. The Student t-test was used for comparison of the level of the metals with standard limits.

III. RESULTS AND DISCUSSION

The questionnaire was obtained from 10 farms in Al-Muwalih market. The result of the questionnaire is shown in Table 1.

Free rearing of cattle is widely practiced in the Western parts of Sudan where large number of animals are raised in that area. This involves taking animals from one place to another in search for water and pasture especially during the rainy seasons. During this period animals can pick toxic substances (including heavy metals) from different sources such as the environment , feeding on contaminated fodder or from waste dumps, drinking polluted water from drains and streams, and intake of atmospheric depositions, especially from vehicular emission and fumes from the open burning of wastes [17]. Following that period, animals are transported to big cities for slaughter ,mainly on hoof (80% of the animals) and this journey may last for two months (Table 1).

Regarding minerals level, Cd was detected in all samples studied (Fig.1).The concentration of Cd in kidney was the highest with a mean of 0.030±0.0029 mg/g, and the least concentration was detected in feed 0.0114±0.0023 mg/g. It's

concentration was significantly higher (P<0.05) than permissible limits [18] in all tissues. Previous studies also showed levels of Cd -exceeding the acceptable limits -in animal tissues such as kidney , liver and muscle [8-19-20-21] . Several studies reported a variation in Cd levels: within the permissible limit [22] , below limit [23], or even not detected [24]. Regarding Pb, it was also detected in all samples (Fig.2) and the highest concentration was found in the kidney with a mean of 0.259±0.0082 mg/g and the least concentration was detected in feed (0.1142 ± 0.00952 mg/g).

Similar to Cd ,Pb concentration in all samples exceeded the permissible limits [18]. Other studies also reported Pb levels exceeding the permissible limits in animal tissues[17,25,26]. In contrast, one study reported Pb levels within the recommended limit [22] , another reported levels below the limits [27] or no Pb was detected in tested meat samples [24].

TABLE I. QUESTIONNAIRE RESULT

NO	Question	Response
1.	Geographical origin of the Animals	Neyala 50% Aldyein 50%
2.	Animal Age	2-3 years 60% 3-4 years 40%
3.	Rearing system(at the original area)	free rearing (Open) 100% Close 0%
4.	Is the grazing area located nearby a war zone?	Yes 30% No 70%
5.	Are there any factories near the grazing area	Yes 10% , No 90%
6.	What are the type of factories	Seeds oil factory
7.	What is the source of water on original farm	Wells 50% Surface water 50%
8.	How are the animals transported to Omdurman locality?	on hoof 80% by vehicles 20%
9.	The duration of transporting livestock from west region to Omdurman locality on hoof	50 - 60 days 90% 60 - 70 days 10%
10.	How long are the animals kept in Al Muwalih before slaughtering	1-2 weeks 20% 2-4 weeks 60 % 4-6 weeks 20%
11.	What is the type of roughage do the animal feed on during this period?	Sorghum straw
12.	What is the component of concentrate do the animal feed during this period	Ground nut cake ,Cotton cake Sunflower cake, wheat bran sorghum cobs
13.	What is the main source of water	Well water stored in tanks 100%
14.	Nature of the barrels?	Iron barrels 70% plastic barrels 30%

In this study, the kidney and liver were found to have the highest concentrations of Cd and Pb (Fig.1and Fig.2).These organs mainly function in storing and removing toxic metals from the body [4-16-28-29] .The level of heavy metal in tissues is affected by different factors such as the duration of exposure

to the heavy metal, genetic characteristics of the animals, breed and age of the animal at slaughter time, geographical conditions, the composition of animal feed, and husbandry practices and whether animals are fattened up close to industrial areas [30-31-32].

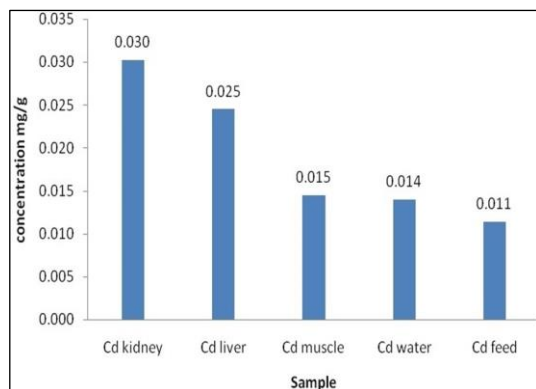


Fig 1. Level of Cd in different samples

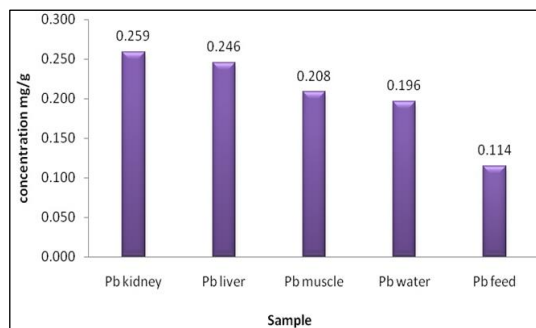


Fig 2. Level of Pb in different samples

In the current study, most animals were between 2-3 years old (Table 1) and were reared in the same geographical area. A previous study reported that Pb (in the muscle and liver) increase with age [33], and another study reported the highest Cd level was in 4 year old cattle [30]. Although, the age related differences in the content of different metals in deer was also confirmed, but the directions of changes were inconsistent [34].

Availing safe and clean water is very important and groundwater is one of the most valuable freshwater sources and is being used for drinking purposes throughout the world [35, 58]. Analysis of water samples collected from Al- Muwalih area showed high concentrations of Cd (0.014 ± 0.003 mg/g). The concentration exceeded the permissible limits [18] and similar results were also reported [36,37]. In Sudan, one study reported high levels of Cd in water [38] while another study showed Cd level within the acceptable limits [39]. Other studies showed Cd below the limits [40-41]. Cd found in water may originate from both natural (weathering of bedrock) and anthropogenic sources such as mining, agriculture and domestic wastewaters, various industrial activities and atmospheric deposits [42-43-44].

High concentrations of Pb in water samples was also detected (0.196 ± 0.015 mg/ml) which was higher than the acceptable limits [18]. Similar studies also showed high concentrations of Pb exceeding permissible limits [39-45-46-

47], while others showed lower levels or even undetected [40,41,48].

In the current study, the farm owners depended mainly on wells or surface water at their original site, but tend to use water stored in tanks or obtained from wells when they reach the capital city (Table 1). During transportation of animals, the main water source is rain water or springs. Rainwater is an important source of fresh water especially for those who live in rural areas and rainwater harvesting is necessary in areas having significant rainfall but lacking conventional water supply systems[2]. Water is usually stored in various containers such as metal or plastic tanks, clay pots and cement reservoir, these methods of storing or preserving water may lead to water contamination. In the current study 80% of the farm owners store water in iron barrels. Heavy metals especially lead can originate from corrosion of plumbing and metal tanks[49].

The level of Cd and Pb was also detected in all feed samples collected from farms in Al-Muwalih area with concentration of $0.011 \pm .002$ mg/g, $0.114 \pm .001$ mg/g respectively. Both levels exceeded the permissible limits [18]. As shown in Table 1, the main feed material was ground nut cake, cotton and sunflower cake, wheat bran and sorghum cobs. Plants usually absorb metal from the soil and air around which may result in accumulation of metals within different plant parts [50], and thus they may enter the body of farm animals and eventually humans get exposed to heavy metals when consuming contaminated animal products [51]. In the current study, some of the grazing areas at the western region are located near war zone (this area suffered from civil war for a long time), and the remnants of war ammunition may stay in the soil for long time in the form of various metal objects that represent a serious hazardous waste [52]. Also some farms were located near factories (Table 1), which can lead to air pollution and further deposition of metals in the soil. It has been reported that contamination of food may be affected by raising animals near contaminated areas [53]. High levels of heavy metals was found in fodder and milk of cattle raised in polluted areas as compared to animals raised in unpolluted areas[54]. Thus, mineral levels can be affected by the soil characteristics of the region, the contamination status of pasture lands and use of water with industrial wastes [55-56] which can increase the risk of transferring minerals to plants and eventually to consumers.

IV. CONCLUSION

The current study showed high levels of Cd and Pb in bovine tissues, water and feed. The highest level was detected in kidney and liver. The consumption of these tissues may pose a health hazard if consumed in large quantities due to bio accumulation of heavy metals in the body.

REFERENCES

- [1] Aycicek M, Kaplan O, and Yaman M".Effect of cadmium on germination, seedling growth and metal contents of sunflower: .Asian J Chem 20:pp2663-2672.,2008.
- [2] WHO, Cadmium, In: Safety Evaluation of Certain Food Additives and Contaminants, Fifty-Fifth Meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA) 2011.
- [3] Akan, J.C., Abdurrahman, F.I., Sodipo, O.A., and Chiroma. Y.A. ". Distribution of Heavy Metals in the Liver, Kidney and Meat of Beef, Mutton, Caprine and Chicken from Kasuwan Shanu Market in Maiduguri

- Metropolis, Borno State, Nigeria.” *Res J App Sci, Engin and Tech*; 2(8), pp. 743-748. 2010.
- [4] Akoto, O, Bortey-Sam, N., Nakayama, S.M.M., Ikenaka, Y., Baidoo, E., Yohannes, Y.B., Mizukawa, H and Ishizuka, M. “Distribution of Heavy Metals in Organs of Sheep and Goat Reared in Obuasi: A Gold Mining Town in Ghana”. *Int. J. Environ. Sci. Toxic. Res.* Vol. 2(2)pp:81-89.,2014
 - [5] Arroyo, G., and Arroyo, J.A.,” Efficiency of different enrichment and isolation procedures for the detection of Salmonella serotypes in edible offal”. *J. Appl.Bacteriol.* 79, pp360-367.,1995.
 - [6] Cordain L, Eaton SB, Miller JB, Mann N, and Hill K. “.The paradoxical nature of hunter gatherer diets: Meat-based, yet non atherogenic”. *European Journal of Clinical Nutrition.* 56(S1):S42,2002.
 - [7] PMC, and Vicente AFR.. “ Meat nutritional composition and nutritive role in the human diet”. *Meat Science.* 93(3):pp 586-592,2013.
 - [8] Mahdih R. “ Determination of some heavy metals concentration in species animal meat (sheep, beef, turkey, and ostrich) and carcinogenic health risk assessment in Kurdistan province, western Iran”. *Research square* .DOI: <https://doi.org/10.21203/rs.3.rs-407310/v1>, 2020.
 - [9] Ayar A, Sert D, and Akin N. “The trace metal levels in milk and dairy products consumed in middle Anatolia-turkey”. *Environmental monitoring and assessment* 152:112,2009.
 - [10] Qin L-Q, Wang X-P, Li W, Tong X and Tong W-J.”The minerals and heavy metals in cow's milk from China and Japan”. *Journal of health science* 55:pp300-305.,2009.
 - [11] Fathy A, Khalafalla, Fatma H, Ali, FrediSchwagele and Mariam A. Abdel-El- Wahab, “. Heavy metal residues in beef carcasses in Beni-Seuf abattoir, Egypt”, *VeterinariaItaliana*; 47(3):pp 351-361,2011.
 - [12] Binkowski, L.J. “The effect of material preparation on the dry weight used in trace elements determination in biological samples” *.Fresenius Environ. Bull.*, 21:pp 1956-1960,2012
 - [13] Okoye C. O. B. and Ugwu J. N.,” Impact of environmental cadmium, lead, copper and zinc on quality of goat meat in Nigeria”. *Bulletin of the Chemical Society of Ethiopia*, vol. 24, no. 1, p. 133-138,2010.
 - [14] Bernard. A.”Cadmium and its adverse effects on human health ,” *Indian Journal of Medical Research.* 128. pp. 557-564 .,2008.
 - [15] Rubio C, González-Iglesias T, Revert C, Reguera JI, Gutiérrez AJ, and Hardisson A.”. Lead dietary intake in a Spanish Population (Canary Islands). “*Journal of Agricultural and Food Chemistry*, 53pp:6543-6549.,2005
 - [16] Abou-Arab, A.A.K.” Heavy metal contents in Egyptian meat and role of detergent washing on their levels”. *Food and Chemical Toxicology*39:pp593-599 ,2001
 - [17] Ihedioha .J.N. Okoye , COB . “Cadmium and Lead levels in muscles and edible offal of cow reared in Nigeria”. Department of Pure and Industrial chemistry , University of Nigeria ,Nsukka, Nigeria.2012
 - [18] FAO/WHO . CXS 193-1995. Adopted in 1995 and amended in (2019) . General standard for contaminants and toxins in food and feed. 47-49 .
 - [19] Amra Colic ,Sejad Mackic ,Nihada Ahmetovic,Boris Antunovic, Aida Sukalic and Edisa Brkic. ‘ Human health risk assessment of cadmium from cattle meat and offal in Central Bosnia Canton”. *Agricultural Conspectus Scientificus* 82 (3) pp315 -320.,2019.
 - [20] Keneth Iceland Kasozi, Yunusu Hamira, Gerald Zirintunda, Khalaf F. Alsharif, Farag M. A. Altalbawy.”.Descriptive Analysis of Heavy Metals Content of Beef From Eastern Uganda and Their Safety for Public Consumption. Page 5-6. Department of Animal Production and Management, Faculty of Agriculture and Animal Sciences, Busitema, Uganda.2020.
 - [21] Aljazzar, A., El-Ghareeb, W.R., Darwish, W.S. et al. “Content of total aflatoxin, lead, and cadmium in the bovine meat and edible offal: study of their human dietary intake, health risk assessment, and molecular biomarkers”. *Environ Sci Pollut Res* 28, 61225–61234 .,2021
 - [22] Musa Yakubu, Nita Dyola , Emmanuel Andrew, Galo Yahaya Sara, Louis Hitler, Innocent Joseph “Determination of the Level of Heavy Metals in Liver and Kidney of Cow and Goat Used As Meat Source in Mubi Adamawa State “ Department of Chemistry, Adamawa State University, Mubi, Adamawa State, Nigeria page 4-5.2017
 - [23] Alaa Eldin Morshdy , Rasha M El Bayomi, Ghada M Abd El Galil , Abdalla Fa Mahmoud . ,” Heavy metal concentration and their risk assessment in marketed slaughtered animals in Sharkia Governorate,Egypt”.*Slovenian Veterinary Research* 55 . 2018
 - [24] Biel, Ewa Czerniawska,tkowska , Alicja Kowalczyk “Offal Chemical Composition from Veal, Beef, and Lamb Maintained in Organic Production Systems. Page 4-7.2019
 - [25] Gulsanga, Zahin Anjum, Sahib Alam and Farhat Shehzad1 Heavy Metals and Mineral Contents of Beef Sold at University Campus, Peshawar, Khyber Pakhtunkhwa, Pakistan, Department of Food and Nutrition, College of Home Economics, University of Peshawar, Khyber Pakhtunkhwa,page 473-474. 2017.
 - [26] Hillary – Frances Ladidi Gwani,Emmanuel Teryila Tyokumbur. ” Appraisal of heavy metals (lead and cadmium) in muscles and internal organs of cattle slaughtered in Ibadan” . *American Journal of Zoology:* (1-5). 2019.
 - [27] Vladimir Tomovic, Marija Jokanovic,Mila Tomovic ,Milana Lazovic, Branislav Soic “ Cadmium and lead in female cattle livers and kidneys from Vojvodina. Northern Serbia”. *Food additives and contaminants Part B* 10 (1) 39 -43,2017.
 - [28] Santhi D, Balakrishnan V, Kalaikannan A, Radhakrishnan KT “ Presence of heavy metals in pork products in Chennai (India)”. *Am. J. Food Technol;* 3(3), pp. 192-199,2008.
 - [29] Blanco-Penedo JL, Benedito RF, Shore M, Miranda M, García V, López-Alonso M. “Influence of farm type (organic, conventional and intensive) on toxic metal accumulation in calves in NW Spain. *Agron. Res.* 7:578-584,2009.
 - [30] Hayrunnisa ÖZLÜ and Mustafa Atasever. “Effects of age and breed on trace elements content in cattle muscle and edible offal”.*Asian J. Med. Biol. Res.* 4 (2), pp157-163,2018.
 - [31] Gálvez, F.; López-Alonso, M.; Herrero-Latorre, C.; Miranda, M.; Franco, D.; Lorenzo, J.M. “Chemometric characterization of the trace element profile of raw meat from Rubia Gallega x Holstein Friesian calves from an intensive system”. *Meat Sci.* 149, pp63–69.,2019.
 - [32] Iketut Berata, Ninyoman Werdi Susari , I wayan Sudira, Kadek Karang Agusgita” Level of lead contamination in the blood of Bali cattle associated with their age and geographical location “. Department of Veterinary Pathology, Faculty of Veterinary Medicine, Universitas Udayana.2021
 - [33] Cygan-Szczegieliak, D., Stasiak, K “Effects of age and sex on the content of heavy metals in the hair, liver and the longissimus lumborum muscle of roe deer *Capreolus capreolus* L.” *Environ Sci Pollut Res* 29,pp 10782–10790, .2022
 - [34] García MHD, Moren DH, Rodríguez FS, Beceiro AL, Álvarez LEF, López MP. “ Sex-and age dependent accumulation of heavy metals (Cd, Pb, and Zn) in liver, kidney and muscle of roe deer (*Capreolus capreolus* L.) from NW Spain. *J Environ. Sci Health A* 46(2):109–116,2011
 - [35] Chabukdhara M., Gupta S.K., Kotecha Y. and Nema A.K. “ Groundwater quality in Ghaziabad district, Uttar Pradesh, India: Multivariate and health risk assessment” *Chemosphere*, doi:10.1016/j .2017.
 - [36] Arain M.B., Kazi T.G., Baig A., Afridi H.I., Brehman S.K.D., Panhwar H. and Arain S.” Coexposure of arsenic and cadmium through drinking water and tobacco smoking: Risk assessment on kidney dysfunction”, *Environmental Science and Pollution Research*, 22, 350-357. doi: 10.1007/s11356-014-3339-0.,2014
 - [37] Atta Rasool,Abida Farooqi,Tangfu Xiao,Sajid Masood,Muhammad Aqeel Kamran” Elevated levels of arsenic and trace metals in drinking water of Tehsil Mailsi, Punjab, Pakistan” *Journal of Geochemical Exploration* 169,pp 89-99.,2016
 - [38] Salwa, M.E., Sara, A.M., Samia, H.A., Abdalla, E.B., Manal, Y.I., Samia, A.H., & Hala, E.A. “Heavy Metals Contaminants in Water and Fish from Four Different Sources in Sudan”. *Journal of Infectious Diseases & Therapy.* 4(275),.2016.
 - [39] Fatima Siddig Musa, Abdelrahim Idris Abdelrahim and Hind Abd El aziz Elnasri “ Determination of Lead and Cadmium concentration in water used by food providers in Bahri Locality- Sudan “. *EAS J Nutr Food Sci* .2(2)33-38,2020.

- [40] Omer A.B.M.” Effect of Khartoum City for Water Quality of the River Nile”. Master Thesis, Department of Water and Environment Studies, Linkoping University, Linkoping Sweden.m2007.
- [41] Olcay K., Nuran C. Y., Numan Y., & Nilgun T. . “Assessment of Some Heavy Metals in Drinking Water Samples of Tunceli, Turkey”, *E - Journal of Chemistry*, 8 (1), pp 276-280.,2011.
- [42] Krishna A.K. and Mohan K.R. “ Risk assessment of heavy metals and their source distribution in waters of a contaminated industrial site,” *Environmental Science and Pollution Research*, 21, pp3653–3669.2014.
- [43] Han, Z., Ma, H., Shi, G., He, L., Wei, L., Shi, Q., “A review of groundwater contamination near municipal solid waste landfill sites in China”. *Sci. Total Environ.* 569,1255–1264,2016.
- [44] Tayebi, L. and Sobhanardakani, S. “ Analysis of Heavy Metal Contents and Non-carcinogenic Health Risk Assessment through Consumption of Tilapia Fish (*Oreochromis niloticus*).” *Pollution*, 6(1),pp59–67.2020.
- [45] Balli and Leghouchi. “ Assessment of lead and cadmium in groundwater sources used for drinking purposes in Jijel (Northeastern Algeria)” page 419-420 , Department of Biological Sciences of the Environment, Faculty of Nature and Life Sciences, University of Abderrahmane Mira of Bejaia, Algeria. 2018.
- [46] Mobarok Hossain, Pulak Kumar Patra “Contamination zoning and health risk assessment of trace elements in groundwater through geostatistical modeling”. *Ecotoxicology and Environmental Safety*. V189 : 110038.,2020
- [47] Hamidreza Farimani Raad, Alireza Pardakhti and Hamidreza Kalarestaghi .” Carcinogenic and Non-carcinogenic Health Risk Assessment of Heavy Metals in Ground Drinking Water Wells of Bandar Abbas “. School of Environment, College of Engineering, University of Tehran, page 399-400.2021
- [48] Mohammad Saleh BakerHariri ,Ramadan Husain Abu-Zied,” Factors influencing heavy metal concentrations in the bottom sediments of the Al-Kharrar Lagoon and Salman Bay, eastern Red Sea coast, Saudi Arabia” . *Arabian Journal of geosciences*11(17), 1-12. .2018
- [49] Okonkwo, O. J.; Maribe, F.,” Assessment of lead exposure in Thohoyandou, South Africa. *The Environmentalist* 24: 171-178. 2004.
- [50] Landis WG, Ming-Ho Yu. “ Introduction to Environmental Toxicology; Impacts of Chemicals Upon Ecological System. “Lewis Publishers, CRC Press, LLC. pp. 221-223.2004.
- [51] Pinho S, Ladeiro B. “ Phytotoxicity by lead as heavy metal focus on oxidative stress”. *J Botany* . DOI: 10. 1155/ 2012/ 369572.2012.
- [52] Certini, G., Scalenghe, R., & Woods, W. I”. The impact of warfare on the soil environment.” *Earth-Science Reviews*,127,pp. 1–15,2013.
- [53] Singh R, Gautam N, Mishra A, Gupta R. “. Heavy metals and living systems: An overview.” *Indian journal of pharmacology* 43:246,2011
- [54] Farid, S. and Baloch, M.K.,” Heavy metal ions in milk samples collected from animals feed with city effluent irrigated fodder.” *Greener Journal of Physical Sciences*, 2(2), pp. 36-43.2012
- [55] Tangahu BJ, SR Sheikh Abdullah, H Basri, M Idris, N Anuar and M Mukhlisin,” A review on heavy metals (As, Pb, and Hg) uptake by plants through phytoremediation.” *Int. J. Chem. Eng.*pp. 1-312011.
- [56] Trujillo-González J, J Mahecha-Pulido, M Torres-Mora, E Brevik, S Keesstra and R Jiménez-Ballesta, (2017).Impact of potentially contaminated river water on agricultural irrigated soils in an equatorial climate. *Agriculture*, 7: 52.,2017
- [57] Q. Yang, L. Zhang, H. Wang, and J. D. Martín, “Bioavailability and health risk of toxic heavy metals (As, Hg, Pb and Cd) in urban soils: A Monte Carlo simulation approach,” *Environmental Research*, vol. 214, p. 113772, Nov. 2022, doi: 10.1016/j.envres.2022.113772.
- [58] G. M. Osiakwan, E. K. Appiah-Adjei, A. T. Kabo-Bah, A. Gibrilla, and G. Anornu, “Assessment of groundwater quality and the controlling factors in coastal aquifers of Ghana: An integrated statistical, geostatistical and hydrogeochemical approach,” *Journal of African Earth Sciences*, vol. 184, p. 104371, Dec. 2021, doi: 10.1016/j.jafrearsci.2021.104371.
- [59] G. I. Ogu, J. C. Igborgbor, U. E. Anana, and G. I. Ogu, “Chemical and microbiological quality of commercial fresh and frozen chicken drumstick in Umuhia, Nigeria,” *International Journal on Food, Agriculture and Natural Resources*, vol. 3, no. 3, pp. 18–27, Dec. 2022, doi: 10.46676/ij-fanres.v3i3.113.