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Levels of Pb, Cd, Zn, Cu and Cr in farm soils of Yorro Local Government of Taraba State, Nigeria

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ABSTRACT: The objective of this paper is to evaluate the levels of Pb, Cd, Zn, Cu and Cr in farm soils of Yorro Local Government of Taraba State Nigeria using atomic absorption spectrophotometer model AASOPM 2015 after complete digestion with aqua regia (HCl and H_2SO_4 in 3:1 ratio). Heavy metals (Pb, Cd, Zn, Cu and Cr) were examined in soil samples from five different sampling points of Kassa village, with Mean concentrations of Zn (7.40±0.02 mg/kg), Cu (4.43±0.06 mg/kg), Cr (0.56±0.00 mg/kg), Pb (0.03±0.00 mg/kg), Cd (0.02±0.00 mg/kg), and five different sampling points from Kunzang village were also examined with mean concentration of Zn (26.90±0.12 mg/kg), Cu (3.54±0.02 mg/kg), Cr (0.52±0.01 mg/kg), Pb (0.06±0.00 mg/kg), and Cd (0.02±0.00 mg/kg). The heavy metals analyses showed that the mean values of all the heavy metal were below Environmental Protection Agency, (EPA, 2015) values. This shows that the soil is safe for Agricultural use.

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According to Chandak *et al.*, (2017) soil forms the intermediate zone between the atmosphere and the rock cover of the earth, the lithosphere. It also forms the interface between water bodies (hydrosphere), the lithosphere and thus forming a part of biosphere. Chandak *et al.*, (2017) soil defined as the uppermost weathered layer of the earth's crust in which are mixed organisms and products of their death and decay. It may also be defined as the part of the earth's crust in which plants are anchored. The soil is a complex organization being made up of some six constituents‟ namely inorganic matter, organic matter, soil organisms, soil moisture, soil solution and soil air. The soil pollution due to sewage is also very high. Several diseases are inflicted in human beings due to pathogenic forms present in the soil. (Kekane *et al.*, 2015). Soil pollution is defined as the presence of toxic chemicals (pollutants or contaminants) in soil, in high enough concentrations to pose a risk to human health and/or the ecosystem. Soil pollution is said to occur if the levels of the contaminants in soil exceed the levels that should naturally be present (Edwin *et al.*, 2017). There are two major causes of soil pollution which are;

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Anthropogenic (man-made) causes and natural causes (Edwin *et al.,* 2017). Soil serves a vital function in nature, providing nutrients for plants to grow, as well as millions of micro and macro organisms. Soil is fundamental to ecosystem, agricultural sustainability and production. It supplies many of the essential requirements for plant growth like water, nutrients, anchorage and oxygen (Osuocha *et al.,* 2016). The disturbance of soil reduces its ability to provide these functions. Soil constitutes part of vital environmental, ecological and agricultural resources that has been protected for the world's increasing population. Soil, being an important component of terrestrial ecosystem supports plant growth and biogeochemical cycling of nutrients and these end up interacting with the soil system thereby changing the physical and chemical properties (Osuocha *et al.,* 2016). According to Wenjun *et al.,* (2015) heavy metal contamination refers to the excessive deposition of toxic heavy metals in the soil caused by human activities. Heavy metals in the soil include some significant metals of biological toxicity, such as mercury (Hg), cadmium (Cd), lead (Pb), chromium (Cr) and arsenic (As), etc. They also include other heavy metals of certain biological toxicity, such as zinc (Zn), copper (Cu), nickel (Ni), stannum (Sn), vanadium (V), and so on. In recent years, with the development of the global economy, both type and content of heavy metals in the soil caused by human activities have gradually increased, resulting in the deterioration of the environment (Zojaji *et al.,* 2018). Heavy metals are highly hazardous to the environment and organisms. It can be enriched through the food chain. Once the soil suffers from heavy metal contamination, it is difficult to be remediated. In the past, soil contamination was not considered as important as air and water pollution, because soil contamination was often with wide range and was more difficult to be controlled and governed than air and water pollution. However, in recent years the soil contamination in developed countries serious and thus paid more and more attention and became a hot topic of environmental protection worldwide (Meravi, 2017).

The objective of this paper is to evaluate the levels of Pb, Cd, Zn, Cu and Cr in farm soils of Yorro Local Government of Taraba State Nigeria.

MATERIALS AND METHODS

Study Area Yorro is a Local Government area in Taraba State, located in North-Eastern Nigeria. Its headquarter is in the town of Kpantisawa. Yorro local government has a land area of about 1,304 km^2 of different land units and has a population of 89,410 (45,548 Male and 43,862 female). According to the 2006 national population census (NPC, 2006). It is located between the latitude 8°53‟0" N and longitude 11°33‟0" E with an elevation of 802m above sea level. Yorro and its immediate environments lie within the Woodland Savannah and Mountain Grassland Vegetation, with heavy annual rainfall of about 800 to 1000 mm and the average daily temperature ranging from 22 to 35°C, before the onset of the rains in late March to October followed by a dry season from November to early March. It has mainly clay, sandy and loamy soils. The Local Government area was created in 1991 and has the following major towns and communities which includes; Kpantisawa, kpantinapo, Garin Malam Audu, Lankaviri, Dankun, Kunzang, Nyalapa, Nyaja, Kassa, Kayya, Gampu etc. The local government is dominated by Mumuye people which are the major ethnic group in the State. The inhabitants of this area are predominantly Hunters, Traders, and Commercial farmers cultivating crops such as Groundnut, Yam, Maize, Cassava and Guinea Corn. It is divided into different communities and towns. In this study, two villages were randomly selected; these include Kunzang, and Kassa. The samples were taken via vertical sampling from 0-5cm, 5-10cm, and 10-25cm depth. In two villages of five directions of each village and one at the center that is totally five sampling units from each village. e.g N1 N2 N3, E1 E2 E3, S1 S2 S3, W1 W2 W3 and C1, C2, C3.

Samples Collection and Storage: The soil samples from the various sampling sites in Kassa and Kunzang villages was taken at a depth of 0.5 to 0.25 cm depth each with the help of plastic Parker wash with clean water and allow to dry. Three (3) soil samples were taken from each sampling site. The soil samples were put into polyethylene bags which were all cleaned. The reason was to remove any traces of heavy metals contaminant (Brigden *et al.,* 2018). The soil samples were transported to MAU Chemistry Lab for further treatment.

Sample preparation: Soil samples were air dried to constant weight and grinded using a mortar and pestle, the grinded soil samples were sieved using a 2 mm mesh for each samples. The soil samples were then stored for further analysis of heavy metals.

Digestion of soil samples for Heavy Metals Analysis (Wet acid Digestion method): The method used was adopted by (Ashutosh *et al.,* 2018). About 1g of soil samples was weighed using a weighing balance and place in 250 cm^3 beakers separately and 15 cm^3 of aqua regia (HCl and H_2SO_4 in 3:1 ratio) was added. The mixture was digested at 70°C till the solution

become transparent. The resulting solution was filtered using filter paper and transfer into a sample bottle and diluted to the mark with distilled water. The sample solution was analyzed for heavy metals concentrations of Cr, Zn, Cd, Cu, and Pb using an atomic absorption spectrophotometer (AASOPM 2015).

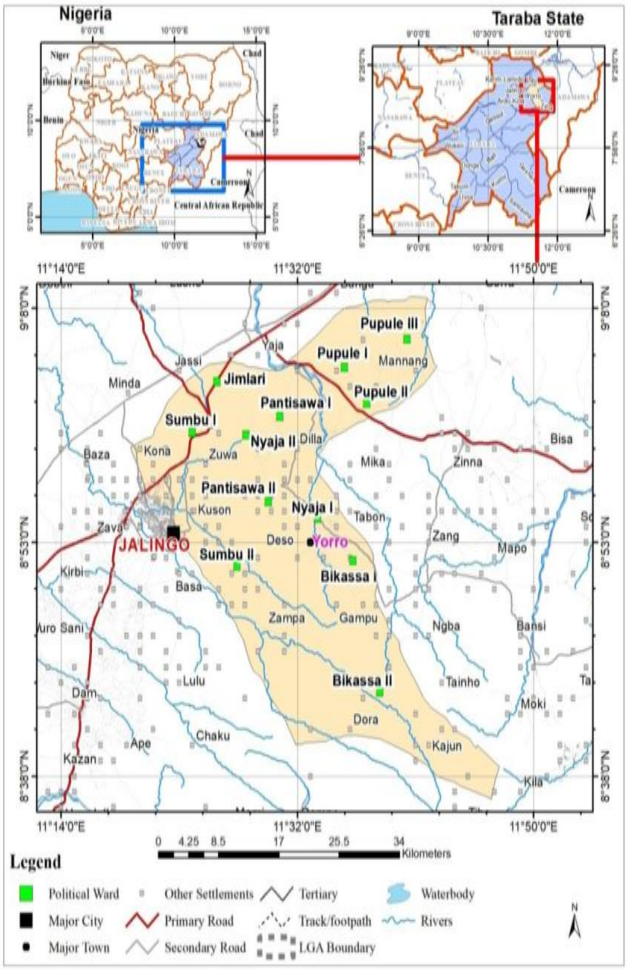


Fig. 1: Map of Yorro Local Government Study Area (Source: Taraba in Map)

Statically Analysis: All the tested parameters were subjected to statistical analysis using SPSS version 20. Means were compared by analysis of variance (ANOVA) followed by Turkey's multiple range test procedures of SAS software version 9.1. All the results obtained were expressed as ± Standard error of the Mean (SEM) of triplicates of each sample and the differences between means were regarded as significant at $P < 0.05$.

RESULT AND DISCUSSION

Lead concentrations values in (mg/kg) recorded for farm soil: The mean concentration of lead in the soil samples are presented in Fig. 2 the results recorded are 0.02±0.01, ±±0.01±0.00, 0.07±0.01, 0.02±0.01, 0.03±0.01, 0.04±0.01, 0.03±0.04, 0.05±0.01, 0.08±0.01, and 0.08±0.01 mg/kg at KSN, KSE, KSS, KSW, KSC, KZN, KZE, KZS KZW and KZC. In all the collected soil samples concentration of lead recorded was below the permissible limit set by EPA (100 mg/kg). These results are in agreement with the results obtained from similar study by Moses (2018) for soil in Zamfara state, Nigeria. The maximum attention has been paid in studying the levels of lead in soil because it is well-known to cause adverse health effects, and is relatively widespread as a result of its historical use in many commercial products and agricultural activities. The low concentrations of lead could be attributed to higher pH, Soil organic matter content, presence of clay minerals, distance from pollution sources, weathering and leaching, microbial activity, and plant uptake of farm soils from the study area.

Cadmium concentrations values in (mg/kg) recorded for farm soil: The mean concentration of cadmium in

the soil samples are presented in Fig. 3 the results recorded are 0.02±0.00, 0.03±0.01, 0.01±0.01, 0.02±0.01, 0.01±0.00, 0.02±0.01, 0.02±0.01, 0.03±0.00, 0.02±0.01, and 0.01±0.00 mg/kg at KSN, KSE, KSS, KSW, KSC, KZN, KZE, KZS KZW and KZC respectively. In all the collected soil samples concentration of cadmium recorded was below the permissible limit set by EPA (3.0 mg/kg). This results obtained are similar with the results obtained from similar study by Isigu (2014) for agricultural soil in Minna Niger state, Nigeria. The low concentrations of Cadmium could be as results of distance from pollution sources, heavy metals in soil decrease as distance from pollution sources increases it could also be as a result of higher pH and soil organic matter or presence of clay minerals.

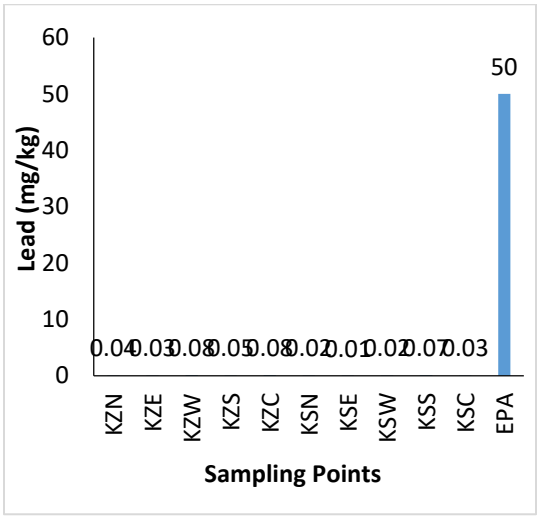


Fig. 2: Mean concentrations of lead values in (mg/kg) recorded for farm soil.

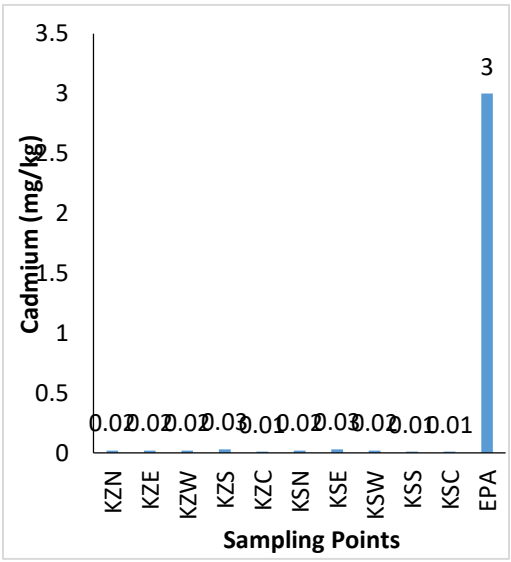


Fig. 3: Mean concentrations of cadmium values in (mg/kg) recorded for farm soil.

Zinc concentrations values in (mg/kg) recorded for farm soil: The mean concentration of zinc in the soil samples are presented in Fig. 4 the results recorded are 3.60±0.04, 4.61±0.06, 0.46±0.03, 23.84±0.05, 4.26±0.06, 33.40±0.01, 9.65±0.07, 50.72±0.02, 21.60±1.49, and 19.04±0.02 mg/kg at KSN, KSE, KSS, KSW, KSC, KZN, KZE, KZS KZW and KZC respectively. In all the collected soil samples concentration of zinc recorded was below the permissible limit set by EPA (200 mg/kg). These results are in agreement with the results obtained from similar study by Edwin (2022) for agricultural soil in Ishelu LGA of Ebonyi state, Nigeria. Zinc is used in a number of alloys including brass and bronze, batteries, fungicides and pigments. Zinc is essential growth element in plants and animals but at an elevated level it is toxic to some species aquatic life (WHO, 2004). The low concentrations of zinc from the study area could be as a result of weathering and leaching; natural process like weathering and leaching can reduce heavy metals content in soil.

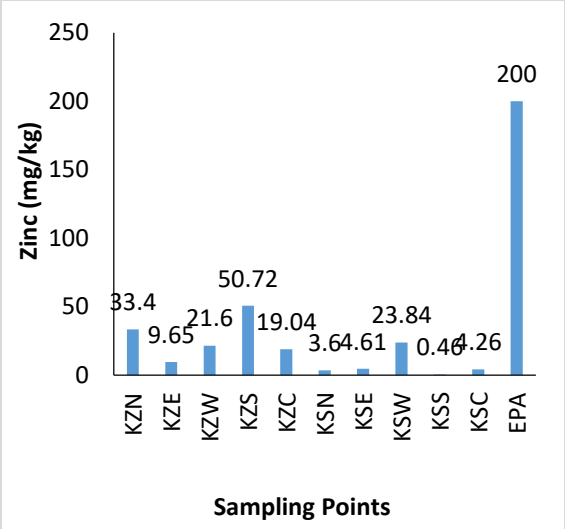


Fig. 4: Mean concentrations of Zinc values in (mg/kg) recorded for farm soil.

Copper concentrations values in (mg/kg) recorded for farm soil: The mean concentration of copper in the soil samples are presented in Fig. 5 the results recorded are 3.60±0.01, 0.67±0.02, 0.43±0.36, 15.64±15.03, 1.82±0.02, 4.09±0.01, 3.23±0.03, 4.60±0.03, 3.12±0.02, and 2.64±0.04 mg/kg at KSN, KSE, KSS, KSW, KSC, KZN, KZE, KZS KZW and KZC respectively. In all the collected soil samples concentration of copper recorded was below the permissible limit set by EPA (50 mg/kg). These results obtained are similar with the results obtained from similar study by Isigu (2014) for agricultural soil in Minna Niger state, Nigeria. The low

concentrations of copper could be as a result of microbial activity; microorganisms can transform heavy metals into less bioavailable forms.

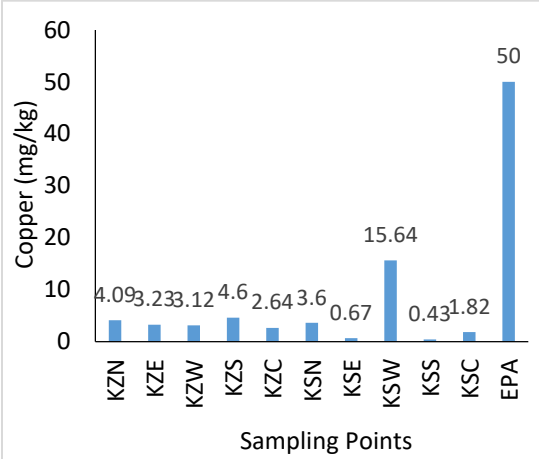


Fig. 5: Mean concentrations of copper values in (mg/kg) recorded for farm soil

Chromium concentrations values in (mg/kg) recorded for farm soil: The mean concentration of chromium in the soil samples are presented in Fig. 6 the results recorded are 0.57±0.02, 0.23±0.02, 0.97±0.02, 0.56±0.02, 0.47±0.03, 0.56±0.01, 0.18±0.00, 0.62±0.02, 0.98±0.02, and 0.26±0.02 mg/kg at KSN, KSE, KSS, KSW, KSC, KZN, KZE, KZS KZW and KZC respectively. In all the collected soil samples concentration of chromium recorded was below the permissible limit set by EPA (100 mg/kg). These results obtained are similar with the results obtained from similar study by Isigu (2014) for agricultural soil in Minna Niger state, Nigeria. In low concentrations, chromium stimulates the growth of agricultural crops, an excess amount of its promotes various diseases. A wide distribution of Chromium in the environment is unfavorable for humans, plants and animals (Vodyanitskii, 2016). The low concentrations of Chromium could be as a result of plant uptake hence; plants can have absorbed heavy metals from soil.

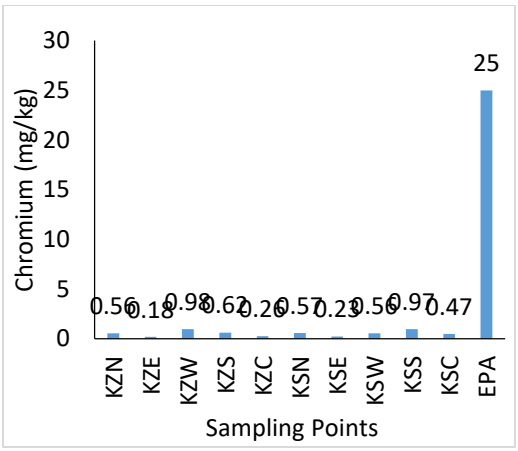


Fig. 6: Mean concentrations of chromium values in (mg/kg) recorded for farm soil

Table 1: Pearson's correlation coefficient (r) matrix for the concentration of different metals in soil samples of Kassa villages Yorro LGA, Taraba state

	Pb	Cd	Zn	Cu	Cr
Pb	1				
Cd	0.764	1			
Zn	0.397	0.231	1		
Cu	0.315	0.133	0.978**	1	
Cr	0.914*	0.727	0.168	0.025	1

*Note: *Correlation is significant at the 0.05 level (2-tailed).*
***Correlation is significant at the 0.01 level (2-tailed).*

Correlation matrix of heavy metals concentrations (mg/kg) in soil samples of kassa village Yorro LGA, Taraba state: Pearson's correlation coefficient was used to examine the relationship between different metals in soil samples around river Nukkai banks, Jalingo, Taraba state. From Table 1, the results of the correlation coefficients showed a strong positive correlation between the lead and cadmium ($r = 0.764$) at $P < 0.01$, a weak positive correlation was also observed between lead and Zinc ($r = 0.397$) at $P < 0.05$, a weak positive correlation was also observed between lead and Copper ($r = 0.315$) at $P < 0.05$, and lastly a strong positive correlation was observed between lead and chromium ($r = 0.914$) at $P > 0.01$. There was a weak positive correlation observed between cadmium and zinc ($r = 0.231$) at $P < 0.05$, and also a weak positive correlation was observed between cadmium and copper ($r = 0.133$) at $P < 0.05$, a strong positive correlation was observed between cadmium and chromium ($r = 0.727$) at $P < 0.01$. A high strong positive correlation was observed between zinc and copper at ($r = 0.978$) at $P < 0.01$, and a weak positive correlation observed between zinc and chromium ($r = 0.168$) at $P < 0.05$. Lastly, a very weak positive correlation was observed between copper and chromium ($r = 0.025$) at $P < 0.05$. This strong positive correlation shows that the metals are closely associated, thus suggesting their common origin. The other metals that shows weak negative or

positive correlation indicating the presence or absence of one metal affect in lesser extent to the other (Rakesh and Raju, 2015).

Table 2: Pearson's correlation coefficient (r) matrix for the concentration of different metals in soil samples of kunzang villages Yorro LGA, Taraba state

	Pb	Cd	Zn	Cu	Cr
Pb	1				
Cd	0.603	1			
Zn	0.868	0.709	1		
Cu	0.637	0.875	0.869	1	
Cr	0.194	0.399	0.403	0.272	1

*Note: *Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).*

Correlation matrix of heavy metals concentrations (mg/kg) in soil samples of kunzang village Yorro LGA, Taraba state: Pearson's correlation coefficient was used to examine the relationship between different metals in soil samples of Kunzang village,Yorro LGA, Taraba state. From Table 2, the results of the correlation coefficients showed a strong positive correlation between the lead and cadmium ($r = 0.603$) at $P < 0.01$, and the same was observed between lead and Zinc ($r = 0.868$) at $P < 0.01$, a strong positive correlation was also observed between lead and Copper ($r = 0.637$) at $P < 0.01$, and lastly a weak positive correlation was observed between lead and chromium ($r = 0.194$) at $P < 0.05$ There was a strong positive correlation observed between cadmium and zinc ($r = 0.709$) at $P < 0.01$, and also a strong positive correlation was observed between cadmium and copper ($r = 0.875$) at $P < 0.01$, while, a weak positive correlation was observed between cadmium and chromium ($r = 0.399$) at $P < 0.05$. A strong positive correlation was observed between zinc and copper at ($r = 0.869$) at $P < 0.01$, and a weak positive correlation was observed between zinc and chromium ($r = 0.403$) at $P < 0.05$. Lastly, a weak positive correlation was observed between copper and chromium ($r = 0.272$) at $P < 0.05$. This strong positive correlation shows that the metals are closely associated, thus suggesting their common origin. The other metals that show weak negative or positive correlation indicating the presence or absence of one metal affect in lesser extent to the other (Rakesh and Raju, 2015).

Comparison between Mean Concentrations of all the Analyzed Heavy Metals in Soil Samples of Kassa and Kunzang Villages, Yorro: Comparison between the total mean concentrations of some analyzed heavy metals in soil samples of Kassa and Kunzang villages are illustrated in Fig. 7. Among all the studied heavy metals in soil samples of Kassa village, Zn was the highest metals detected with the total mean concentration of 7.40±0.02 mg/kg, Cu=4.43±0.06 mg/kg, Cr=0.56±0.00 mg/kg, Pb=0.03±0.00 mg/kg, and Cd=0.02±0.00 mg/kg, respectively. In all the studied soil heavy metals the concentrations recorded in Kassa was found to be below the maximum permissible limit set set by EPA for agricultural soils. However, Zn was also with highest concentrations in soil samples of Kunzang village with total mean concentration of 26.90±0.12 mg/kg, Cu=3.54±0.02 mg/kg, Cr=0.52±0.01 mg/kg, Pb=0.06±0.00 mg/kg and Cd=0.02±0.00 mg/kg respectively. In all the studied heavy metals, the concentrations recorded in Kunzang village was also found below the maximum permissible limit set by EPA for agricultural soils. The total mean concentration of heavy metals in both Kassa and Kunzang villages followed the order; Zn > Cu > Cr > Pb > Cd. It shows that the farm soils are safe for agricultural use. The comparison of the results of heavy metals in soil samples of Kassa and Kunzang villages revealed that the concentrations of these metals are found in soil samples of all the sampling site although, they are all below maximum permissible limits set by EPA for agricultural soil. It shows that the farm soils are safe for agricultural use.

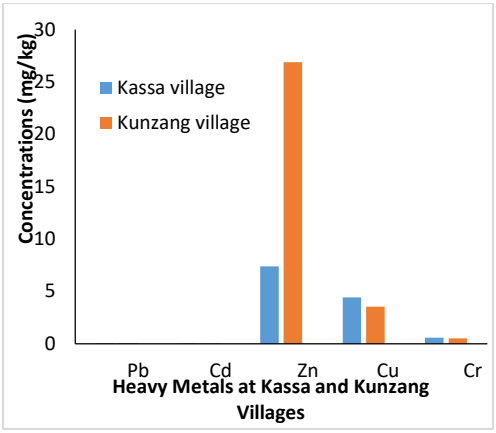


Fig. 7: Comparison between values (mg/kg) of all the analyzed heavy metals in soil samples of Kassa and Kunzang villages, Yorro.

Conclusion: The results of heavy metals analysis in soil samples revealed the presence of heavy metals (Pb, Cd, Zn, Cu, and Cr) in the entire analyzed sample in this study. All the metals were within the safe limit of EPA Maximum limit.

Declaration of Conflict of Interest: The authors declare that no known conflict of interest or personal relationships that could have influence the work reported in this paper

Data Availability: Data are available upon request from the corresponding author or any of the other authors

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