Analysis of Heavy Metals Content of Tobacco and Cigarettes sold in Wa Municipality of Upper West Region, Ghana.

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ABSTRACT
Metals are essential for a number of physiological processes in the human body, but can also be detrimental to our health when the concentration is not within the WHO/FAO/JECFA recommended permissible limits. The contents of selected Heavy Metals in tobacco and cigarette brands sold in the Wa Municipality of Upper West Region of Ghana were determined by Atomic Absorption Spectrometry (AAS). Average concentrations of Arsenic, Lead, Cupper, Iron, Zinc, Manganese, Cadmium, Nickel, Chromium and Selenium in tobacco and different cigarette brands were determined and compared to WHO/FAO/JECFA or other regions permissible limits of the Daily Intake or Provisional Tolerable Weekly Intake of tobacco and cigarettes. The results obtained in this study estimate the mean of Lead, Manganese and Cadmium was slightly higher than the recommended permissible limits of WHO/FAO/JECFA and other regions and the necessary conclusions were drawn.
KEYWORDS: Heavy metals, chronic exposure, Tobacco plants, Cigarettes, Daily Intake.

1. INTRODUCTION
The heavy metals are widely dispersed in the environment, and at excessive levels, are very toxic to humans [1]. Chronic exposure to these substances may also be hazardous. Although these metals occur naturally, exposure may be increased by human activities that release them into the air, soil, water and food, and by-products that contain heavy metals. Certain plants also have the ability to accumulate heavy metals that have no known biological function [2]. Tobacco plant is amenable to absorb and accumulate heavy metal species from the soil into leaves [3]. Tobacco plants transport metal ions from the soil through the roots into the leaves [4], [5]. Trace amounts of heavy metals accumulate in the leaves, and they are known to transfer in trace quantities from the cured and processed tobacco to mainstream cigarette smoke. These metals include cadmium, lead, arsenic, iron, copper, chromium, nickel, and selenium [6], [7], [8]. The most abundant redox inactive metals in cigarette smoke generally are cadmium, lead and arsenic.

Industrialization has contributed to the burden of trace metals in soils in urban areas. Metals that are added from the application of sewage sludge, pesticides, lime, irrigation waters and fertilizers have threatened the quality of agricultural land [9]. Heavy metals are critical in this regard because of their easy uptake into the food chain and bioaccumulation processes [10]. Toxic heavy metal can cause dermatological diseases, skin cancer and internal cancers (liver, kidney, lung and bladder), cardiovascular disease, diabetes, and anemia, as well as reproductive, developmental, immunological and neurological affects in the human body.

Chronic exposure to lead can result in decreased neurological performance. In pregnant women, exposure to high lead levels may cause miscarriage, and chronic exposure may affect the development of the foetus. Methyl mercury may cause numbness and tingling and in the extremities, blurred vision, deafness, lack of muscle coordination and intellectual impairment, as well as adverse effects on the cardiovascular, gastrointestinal and reproductive systems [11].

Tobacco smoking has been identified as a major serious Public health issue and contributes to high mortality and morbidity of both smokers and passive smokers. Some surveys clarified that the contents of certain chemicals especially cadmium in fats, blood and liver tobacco smokers are much higher than those of non-smokers [12], [13], [14]. Tobacco kills approximately 6 million people and causes more than half a trillion dollars of economic damage each year [15].
The purpose of this research is to determine the level of selected heavy metals in tobacco and various brands of cigarettes sold in the Wa Municipality of Upper West Region of Ghana.

1.1 Study Location
The Upper West Region, created in 1983, is one of the youngest regions in Ghana. Before its creation, it was part of the Upper East Region with the Regional Administrative Capital situated at Bolgatanga. The Upper West Region is bordered on the north by Burkina Faso, on the east by the Upper East region, on the south by the Northern region, and shares a common border on the west with Burkina Faso. It is the seventh largest Region in

Ghana in total area, and is made up of nine districts with an estimated population of 2 Million.

Wa Municipality is among the nine Municipalities and District Assemblies in the Upper West Region with its Administrative Capital at Wa. This makes it the largest urban Centre in the region. The Municipality shares boundaries with Nadowli District to the North, Sawla-Tuna-Kalba District to the South, Wa West District to the West and Wa East District to the East. The Upper West region is inhibited predominantly by Moslems with a few Christians and Traditionalists. The region is also inhabited by few immigrants from Burkina Faso who primarily engage in cattle herding and work as farm labourers. The main occupation is farming.

	TOTAL	MALE	FEMALE
GHANA	24,658,823	12,024,845	12,633,978
UPPER WEST	702,110	341,182	360,928
WA WEST	81,348	40,227	41,121
WA MUNICIPAL	107,214	52,996	54,218
WA EAST	72,074	36,396	35,678
SISSALA EAST	56,528	27,503	29,025
NADOWLI	94,388	44,724	49,664
JIRAPA	88,402	41,592	46,810
SISSALA WEST	49,573	24,151	25,422
LAMBUSSIE KARNI	51,654	24,952	26,702
LAWRA	100,929	48,641	52,288

Source: Ghana Statistical Service (GSS)

Fig.1. Population by Sex and Districts.

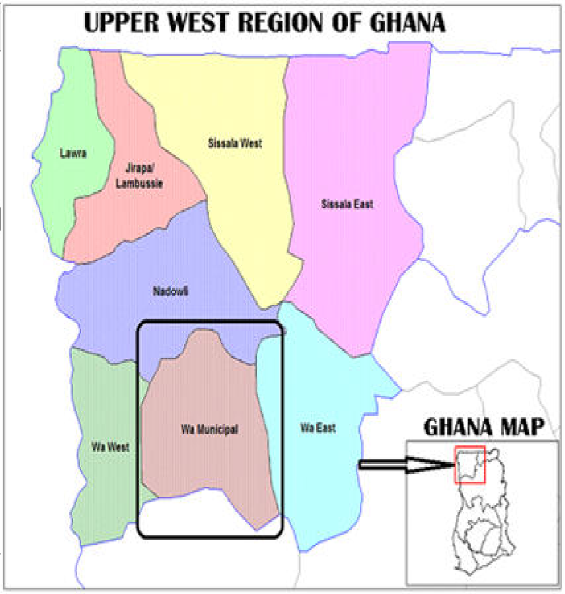

Fig.2. Map of Upper West region.

2.0 METHODS AND MATERIALS

2.1 Sampling

Ten samples were purchased, made up of one raw local tobacco sample and nine brands of Cigarettes. The raw tobacco sample was selected from the main Central market in the Wa Municipality and the remaining samples were purchased from various Bars and Social Outlets in the Wa Municipality.

2.2 Digestion of Tobacco samples

A 1g of a the sample was weighed and placed into 500 ml beaker and 10 ml of di – acid mixture of HNO_3 and $HClO_4$ with ratio 9: 4 was added and the contents well mixed by swirling thoroughly [16], [17], [18].The flask with contents was then placed on a hot plate in the fume chamber and heated, starting at 85^0C and then temperature raised to 150^0C, heating continued until the production of red NO_2 fumes ceased. The contents were further heated until volume was reduced to 3 – 4 ml and became colorless or yellowish, but not dried. This was done to reduce interference by organic matter and to convert metal associated particulate to a form (the free metal) that could be determined by the Atomic Absorption Spectrophotometer (AAS). Contents were cooled and volume made up with distilled water and filtered through Whatman 1 acid-washed filter paper. The resulting solution was preserved at 4^0C, used for Spectrophotometric determination of the various metal analyses.

2.3 Atomic Absorption Spectrophotometry analysis.

AAS 220 model was used in determining the content of heavy metals in the previously digested tobacco samples. The acetylene gas and compressor were fixed and compressor turned on and the liquid trap blown to get rid of any liquid trapped. The Extractor and the AAS 220 power were turned on. The capillary tube and nebulizer block were cleaned with cleansing wire and opening of the burner cleaned with an alignment card. The worksheet of the AAS software on the attached computer was opened and the hollow cathode lamp inserted in the lamp holder. The lamp was turned on; ray from cathode aligned to hit target area of the alignment card for optimal light throughput, then the machine was ignited. The capillary was placed in a 10 ml graduated cylinder containing deionized water and aspiration rate measured, and set to 6 ml per minute. The analytical blank was prepared, and a series of calibration solutions of known amounts of analyte element (standards) were made. The blank and standards were atomized in turn and their responses measured. A calibration graph was plotted for each of the solutions, after which the sample solutions were atomized and measured. The various metal concentrations from the sample solution were determined from the calibration, based on the absorbance obtained for the unknown (AOAC, 2006).

2.4 Pictures showing the raw Tobacco and Cigarettes samples and measured amounts in 500ml beakers.

3.0 RESULTS AND DISSCUSION

3.2 *Discussion of Results*

Arsenic: Tobacco plants essentially take up arsenic naturally present in the soil. The arsenic exposure becomes more prevalent when tobacco plants are treated with lead arsenate insecticide. Inorganic arsenic compounds are highly toxic and carcinogenic and mostly derived from pesticides used in tobacco farming. Long-term exposure to inorganic arsenic can lead to chronic arsenic poisoning, skin lesions and skin cancer. Health implications, including lung cancer, have been well documented. Chronic exposure at levels below the currently accepted threshold of 10mg/l and at such dosage indicating that several people who are exposed to arsenic condition would be affected [20], [21], [22].

The results from the analysis suggests that the arsenic content in tobacco and cigarettes sold in the Wa Municipality (Upper West Region) of Ghana is well below the WHO/FAO recommended daily value of 3mg/kg as shown in Table 2 and well below 0.01mg/L, which is the detection limit level of the AAS machine. This thus implies that the level of arsenic content in tobacco and cigarettes sold in this region is comparable to the threshold values of arsenic in water recommended by a small cohort of study conducted for people exposed to arsenic water in Bangladeshi, Northern Chile and Argentina [23],[24],[25].

Lead: Apart from being absorbed by tobacco plants through the soil as a result of the fallout from the atmosphere, Lead is also absorbed into the soil by accidental means or by deliberate dumping of lead- laden waste, the addition of pesticides and fertilizers that contain lead and also through the processing stages of cigarettes etc. [26].

Lead exposure has also been linked epidemiologically to attention-deficit hyperactive disorder (ADHD) – a condition with symptoms that include inattentiveness, hyperactivity and impulsiveness and certain aspects of aggressive tendencies. Exposure of pregnant women to high levels of lead could also result in fetal miscarriage, stillbirth, premature birth and low birth weight as well as other minor malformations [27], [28].

The mean of the lead content of tobacco and cigarettes sold in the Wa Municipality is 5.823mg/kg with a maximum of 8.3mg/kg and a minimum of 1.53mg/kg as noted in table 1 and fig.3.The WHO/FAO recommended value for daily and provisional tolerable weekly intake is 5mg/kg and 25mg/kg respectively.
This implies that at an intake of more than 5mg/kg and 25mg/kg from the Table 2 for daily and provisional tolerable weekly intake respectively could expose the consumer to the aforementioned conditions. It was found that seven samples SA 1, SA 2, SA 4, SA 5, SA 6, SA 8L and SA 9 have a lead contents which exceed the WHO/FAO permissible daily intake of 5mg/kg with SA 5 and SA 7 being the highest.

Copper: Copper is one of the essential elements for human metabolism. It enters the soil through waste deposit dumps, domestic waste water and the use of phosphate fertilizer for farming. The WHO and FAO recommended values for daily and provisional tolerable weekly intake is 100mg/kg and 500mg/kg respectively. In the Wa Municipality, the mean of the copper contents in tobacco and cigarettes is 14.53mg/kg with the maximum of

21.8mg/kg and the minimum of 10.2mg/kg as noted in tables 1 and fig.4. These are below the WHO/FAO recommended daily and provisional tolerable weekly intake limits.

Iron: Iron is an essential mineral used to transport oxygen to all parts of the body. A slight deficiency in iron causes anemia. A chronic deficiency in this vital mineral can lead to lung and heart failure. The mean of the iron contents in tobacco and cigarettes sold in the Wa Municipality is 227.14mg/kg with the maximum of 480.6mg/kg and the minimum of 193.7mg/kg as shown in table 1 and fig.5.It was found that two samples, SA 8L and SA 10 have the highest values.

Zinc: Zinc is an essential component of various enzyme systems for energy production, protein synthesis, and growth regulation. Zinc deficient plants also exhibit delayed growth. The mean of the zinc contents in tobacco and cigarettes sold in the Wa Municipality is 127.0 mg/kg with the maximum of 277.3mg/kg and the minimum of 49.2mg/kg as shown in table 1 and fig.6. It was found that two samples SA 1 and SA 6 have the highest values of zinc.

Manganese: Manganese is another essential element for humans. Adverse effects can result from both deficiency and overexposure to the mineral. It is known to cause neurological effects following inhalation, exposure, particularly in occupational settings, and there have been epidemiological studies that report adverse neurological effects following extended exposure to very high levels in drinking-water [29].

The mean of the manganese contents in tobacco and cigarettes sold in the Wa Municipality is 14.16.0mg/kg with the maximum of 36.6mg/kg and the minimum of 4.8mg/kg from the table 1 and fig.7. It was found that two samples SA 1 and SA 6 have the highest values of manganese. A study conducted for manganese in drinking water recommends a range of 3.5–7 mg/day for adults based on a review of human studies [30].

National Academies of Science, Institute of Medicine, Food and Nutrition Board suggested average daily requirement for manganese to be 2 – 3 milligrams per day (mg/d) for ages 1- 8 and 6 – 11 mg/d for ages 9 and above[31].It was found that six samples; SA 1, SA 3, SA 6, SA 9 and SA 10 have manganese content which exceeded the National Academies of Science, Institute of Medicine, Food and Nutrition Board permissible daily intake of 11mg/kg with SA 1 and SA 6 being the highest from table 1 and fig 7.

Cadmium: Traces of cadmium can be found in tobacco plants. Most smokers have almost twice the levels of cadmium in their bodies as do non-smokers. Breathing in high doses of cadmium can irritate and damage the lungs and can cause death .Cadmium is efficiently absorbed when inhaled. Cd was found higher than the WHO/JECFA permissible level in all samples, except SA 10 as shown in Table 2. According to WHO/JECFA, the recommended Cd value for a week for adults is 3.5 mg/kg. The cadmium contents in SA 1, SA 6, and SA 9 are the highest.

Nickel: Nickel at the right trace amount, is an essential mineral for human nutrition. Nickel dermatitis is the most common effect in humans from chronic skin contact with nickel. Respiratory effects have also been researched in humans from inhalation exposure to nickel. Soil usually contains 4-80 ppm of nickel. Food is the major source of nickel exposure, with an average intake for adults estimated to be approximately 50 mg/d for drinking water [32], [33]. It is an irritant to the skin, toxic to the cardiovascular system and as well as being carcinogenic. The mean of the nickel content in tobacco and cigarettes sold at the Wa Municipality is 10.74mg/kg with the maximum of 27.8mg/kg and the minimum of 2.2mg/kg as detailed in Table 1 and Fig.8. Nickel contents in the samples were found to be below the maximum permissible limits of 100mg/day.

Chromium: Chromium can exist in several oxidation states, although only the trivalent, Cr (III), and the hexavalent, Cr (VI), forms are common in the natural environment. Chromium content of about 4.3mg/kg (dry weight) is found in smokers compared to 1.3mg/kg in non-smokers, increasing with age and the duration of smoking [34]. The mean of the nickel contents in tobacco and cigarettes sold in the Wa Municipality is 1.90mg/kg with the maximum of 4.0mg/kg and the minimum of 1.0mg/kg as shown in Table 1 and Fig.9. The chromium daily intake of tobacco and cigarettes is comparable to the recommended chromium intake of North Americans which was found to be 60-90 μg/day [35].

Selenium: Although tobacco plants and cigarette smoke contain Selenium, smoking has been shown to reduce blood Se levels [35]. Interestingly, Se has been reported to function as a protective agent for cancers and heart disease. The result from the analysis shows that the selenium content in tobacco and cigarettes sold in the Wa Municipality (Upper West Region) of Ghana is far less than 0.01mg/L, which is below the detection limit level of the AAS machine.

4.0 CONCLUSION

It was realized from the research conducted that all the heavy metals contents measured satisfied the FAO/WHO/JECFA or other regions' recommended permissible limit for daily or provisional tolerable weekly intake of tobacco and cigarettes with the exception of lead, manganese and cadmium which have their means slightly greater than the recommended permissible limits.

This may be due to the environmental conditions prevalent at the time of growing, cultivation and subsequent processing of the tobacco or indeed types of fertilizer used.

5.0 RECOMMENDATION

The Authors recommend that further studies be undertaken on the soil and fertilizers used for the growing and cultivation of tobacco with a view to ascertain the presence and content of these heavy metals. This would help initiate the adoption of more appropriate and effective methods for cultivation and processing of the tobacco plant.

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No	Sample Code	As	Pb	Cu	Fe	Zn	Mn	Cd	Ni	Cr	Se
1	SA1	<1.00	5.5	15.1	171.8	277.3	36.6	4.1	27.8	4.000	<1.00
2	SA 2	<1.00	6.9	11.9	191.4	113.5	7.1	1.2	14.4	1.000	<1.00
3	SA 3	<1.00	4.2	19.9	143.7	68.2	13.1	1.1	3.3	2.000	<1.00
4	SA 4	<1.00	6.9	12.3	168.9	76.3	7.3	1.2	2.2	2.000	<1.00
5	SA 5	<1.00	4.2	12.8	232.1	119.1	11.000	1.1	6.1	1.000	<1.00
6	SA 6	<1.00	8.3	21.8	181.7	258.1	31.3	3.000	24.9	3.000	<1.00
7	SA 7	<1.00	6.9	13.4	200.000	74.1	4.8	1.2	2.6	1.000	<1.00
8	SA 8L	<1.00	1.53	10.2	480.6	108.8	6.000	1.1	9.9	1.000	<1.00
9	SA 9	<1.00	5.5	15.8	151.1	125.4	11.7	3.000	12.6	3.000	<1.00
10	SA 10	<1.00	8.3	12.1	352.8	49.2	12.7	1	3.6	1.000	<1.00
11	SAmean	<1.00	5.823	14.53	227.41	127	14.16	1.8	10.74	1.900	<1.00
12	SAmax	<1.00	64.053	21.8	480.6	277.3	36.6	4.1	27.8	4.000	<1.00
13	SAmin	<1.00	1.53	10.2	143.7	49.2	4.8	1	2.2	1.000	<1.00
	SAstd Deviation		2.09914295	3.7184375	107.15188	78.3403827	10.8920154	1.12348664	9.28657334	1.10050493	
14	Results in mg/Kg										

Table 1. Results of the test.

Permissible Intake Levels as per FAO/WHO Recommendations

Metal	Provisional Tolerable Weekly Intake (μg/kg/week)	Per Day Intake (μg/kg/day)	For a 60-kg Individual (μg/day)	Ref.
Pb	25	5	300	FAO/WHO
As	15	3	180	FAO/WHO
Cd	3.5	0.2–1	30	WHO/JECFA
Cu	500	100	600	FAO/WHO

Table 2. WHO/FAO Standard for Heavy Metal Daily and Provisional Tolerable Weekly Permissible Intake.

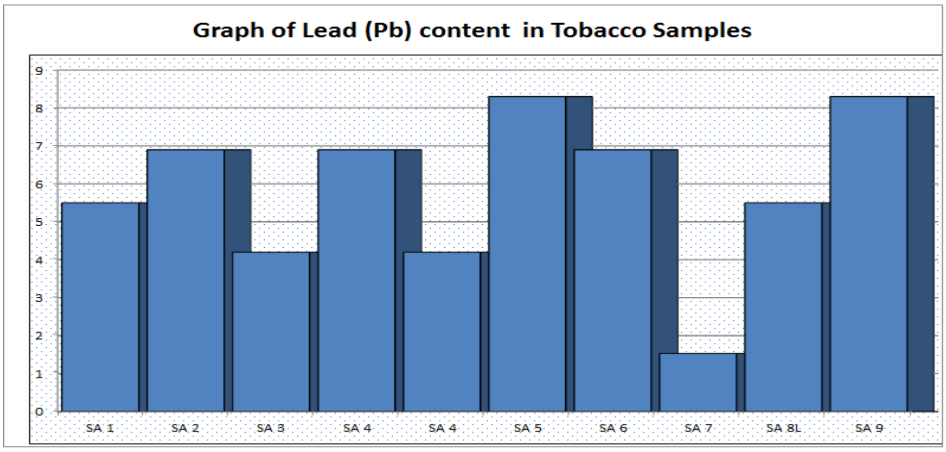

Fig.3. Graph of lead (Pb) content (mg/Kg) in Tobacco Sample.

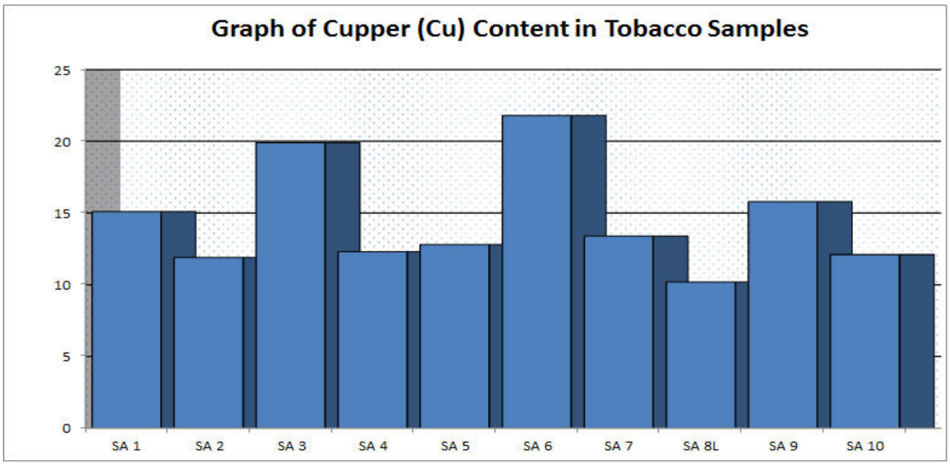

Fig.4. Graph of Copper (Cu) content (mg/Kg) in Tobacco Sample.

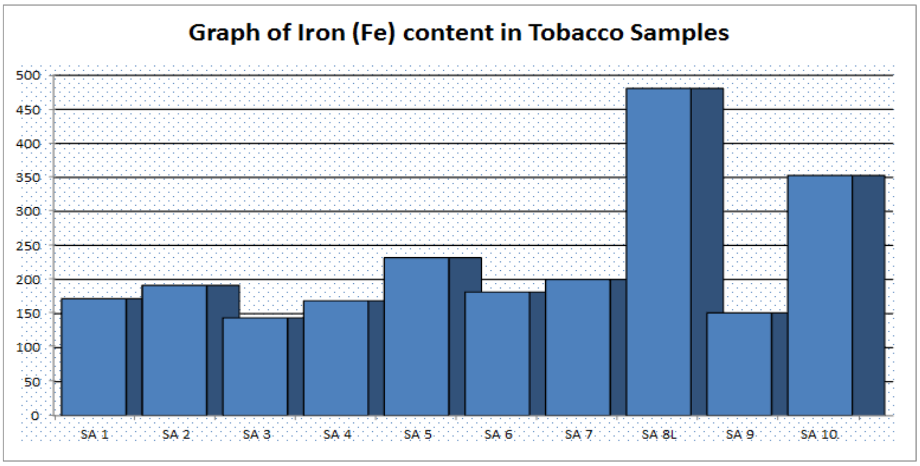

Fig.5. Graph of Iron (Fe) content (mg/Kg) in Tobacco Sample.

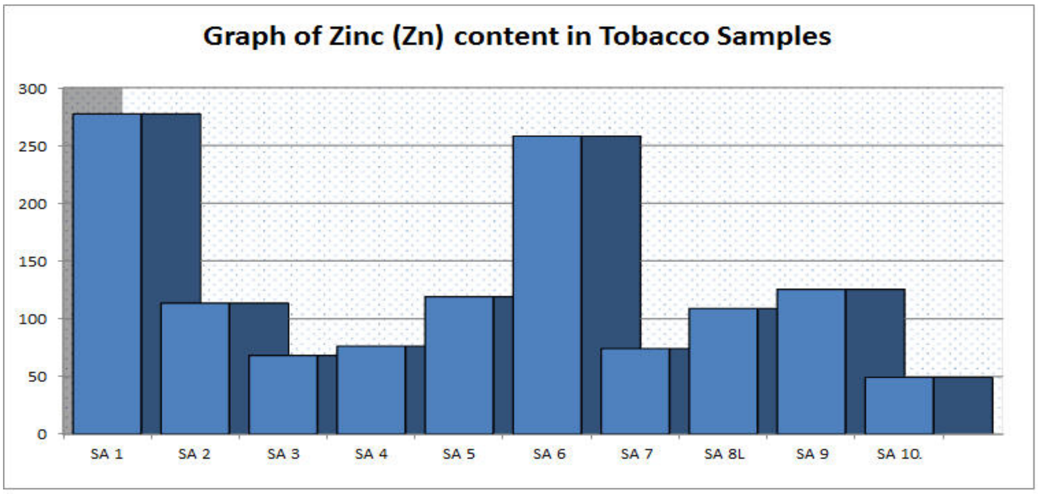

Fig.6. Graph of Zinc (Zn) content (mg/Kg) in Tobacco Sample.

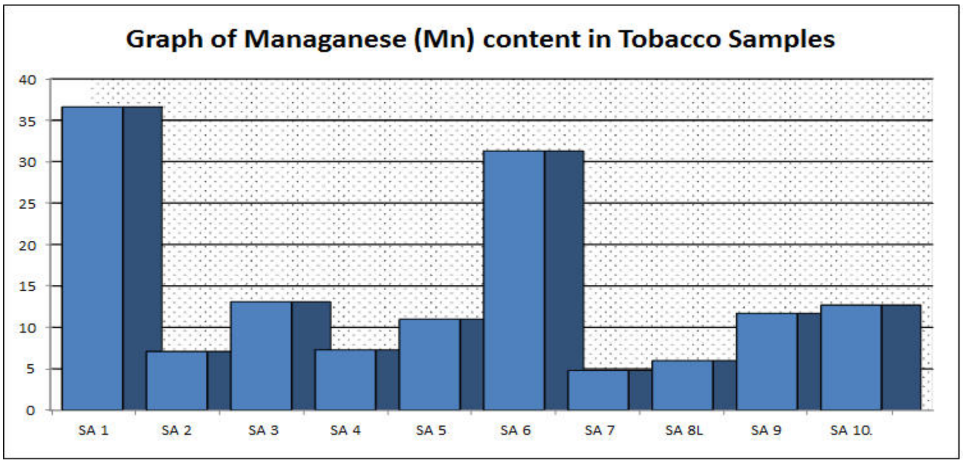

Fig.7. Graph of Manganese (Mn) content (mg/Kg) in Tobacco Sample.

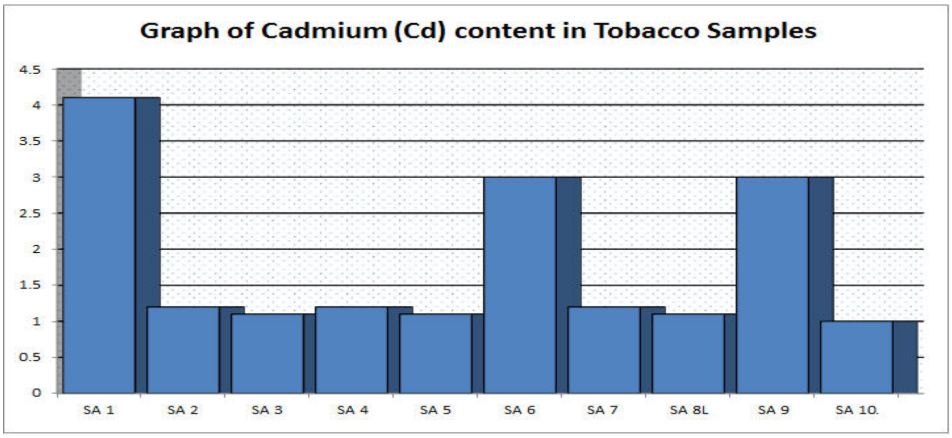

Fig.8. Graph of Cadmium (Cd) content (mg/Kg) in Tobacco Sample

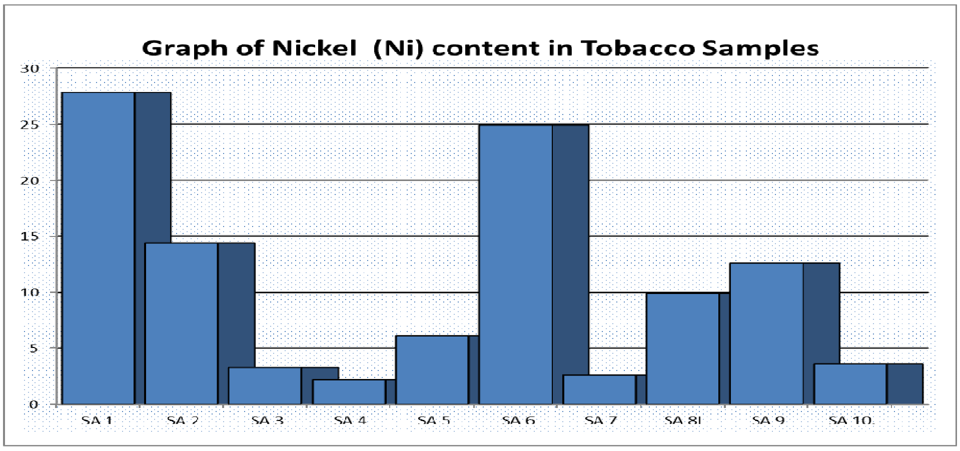

Fig.9. Graph of Nickel (Ni) content (mg/Kg) in Tobacco Sample.

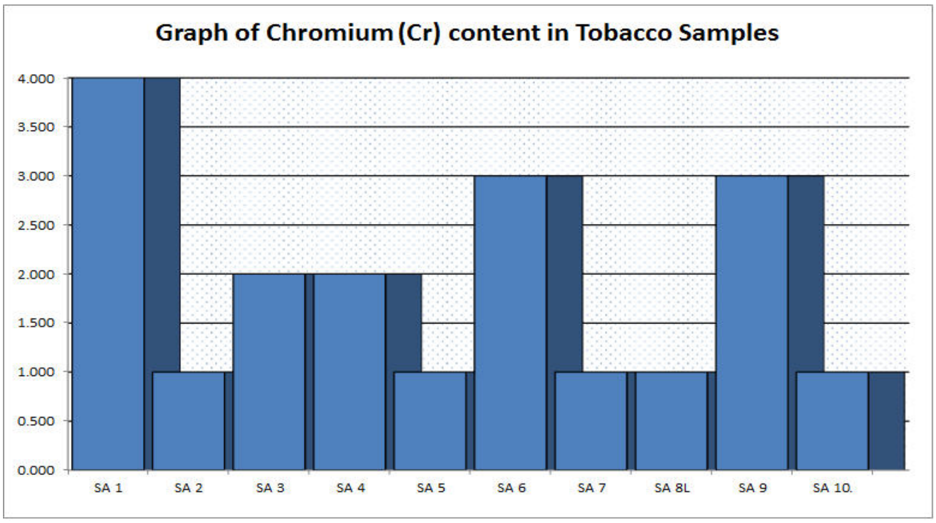

Fig.10. Graph of Chromium (Cr) content (mg/Kg) in Tobacco Sample.

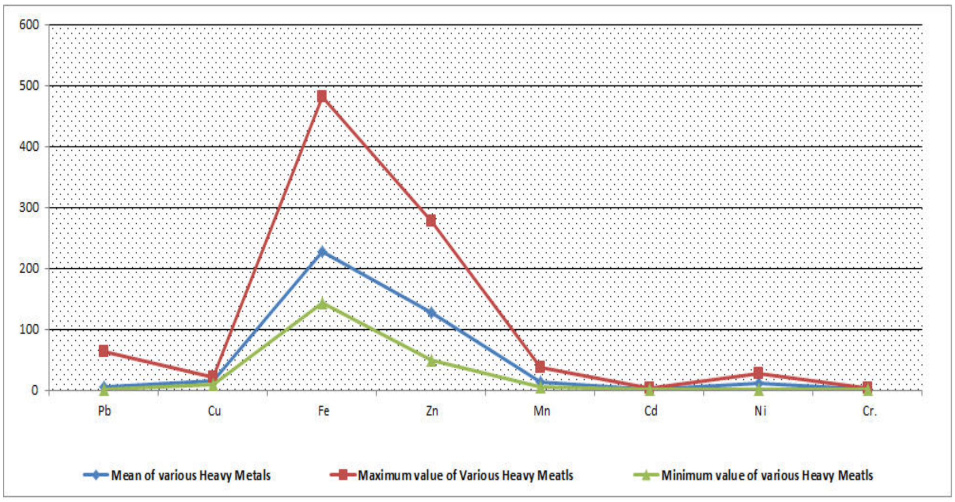

Fig.11. Shows graph maximum, mean and minimum values of various heavy metals in Tobacco Samples.