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Evaluation of Heavy Metal Contamination of Soil, Sediments and Irrigation Water in farmlands of Kilange Stream of Adamawa state, Nigeria.

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ABSTRACT

The heavy metals in soil, sediment, and water along the farmlands of Kilange streams (River) A total of 16 soil, sediments and water samples were collected and analyzed for heavy metals (Zn, Mn, Fe, Cr, Ni, Cd, Pb, Hg, Se, Ag, and As) parameters using standard procedures. Results of heavy metal analysis of soil, sediment and water obtained from eight (8) sampling sites along the farmlands of Kilange in Adamawa State during the wet and dry seasons were found to contain all the analysed heavy metals (except As, Hg, Se, and Ag) at different levels. Concentrations of Pb, Ni, Cd, As, Se, Hg and Ag were not detected soil samples, Ni, As, Se, Hg and Ag were not detected in sediments and Co, As, Cd and Hg were not detected in water samples obtained from eight sampling sites of Kilange both during the wet and dry seasons. However, in sample of sediments Pb was only detected in Wuro Alhaji, Zyhdinyi, Dirwachilla during dry season with a mean concentration of 0.600±0.01mg/Kg 1.240±0.01 mg/Kg, 0.6600±0.01 mg/Kg respectively, Cadmium was only detected in Wuro Yolde during dry season with a mean concentration of 0.530±0.01 mg/Kg and Cr found in Guriki during dry season with a mean value of 0.850±0.01 mg/Kg. They were found to have exceeded the WHO recommended limits. Mn was one of the heavy metal detected in all the sediments samples investigated from the areas around the Kilange Streams. It has a mean concentration ranging from 0.08 mg/kg – 0.25 mg/kg, with the lowest values of 0.08 mg/kg at Muleng during dry season and the highest value of 0.25 mg/kg at Geleng during wet season. Water was also found to contain different levels of the heavy metals. The mean levels of Pb in was only detected in the water samples from Guriki during dry season with a mean value of 0.04±0.001mg/kg, Cr was detected in all the water samples within the range of 0.01 to 0.04 during both wet and dry seasons and concentration of Ni were found to be ranged from 0.07 to 0.1mg/kg in all the sampling sites during both dry and wet season. Mean levels of Pb, Cd and Cr featured in soil, sediments and water samples with concentrations above the recommended limits by WHO.

Keywords: Heavy Metal Contamination of Soil, Sediments and Irrigation Water in farmlands of Kilange Stream of Adamawa state, Nigeria

INTRODUCTION

Pollution is one of the most serious problems around the world today, most especially heavy metals in which thousands of world inhabitants suffer health problems related to industry and atmospheric pollutants. Recent years a significant attention being paid to the problems of environmental contamination by wide variety of chemical pollutants including heavy metals [1,2,3]. For quite a long time, soil has been considered a means with a practically unlimited capacity to accumulate pollutants without immediately producing harmful effects for the environment or for human health. Presently, however, we know that this is not true. Public awareness has been raised on the harmful potential of some soil trace elements, commonly known as heavy metals that can accumulate in crops and may end up in human diet through the food chain. Many studies have confirmed that heavy metals may accumulate and damage crops or even mankind [4,5,6]. Metal distribution between soil and vegetation is a key issue in assessing environmental effect of metals in the environment [7]. Heavy metals toxicity has an inhibitory effect on plants growth, enzymatic activity, photosynthetic activity and accumulation of other nutrient elements, it also damages the root system [8]. Soil is not only a medium for plant growth or pool to dispose of undesirable materials, but also a transmitter of many pollutants to surface water, groundwater, atmosphere and food. Therefore, soil pollution may threaten human health through its effects on the hygiene quality of food and drinking water. Human activities such as industrial production, mining, agriculture and transportation, release high amounts of heavy metals into surface, ground water, soils and ultimately to the biosphere. Heavy metal concentration in the soil solution plays an important role in controlling metal bioavailability to plants. Most of the studies show that the use of waste water contaminated with heavy metals for irrigation over long period of time increases the heavy metal contents of soils above the permissible limit. Ultimately, increasing the heavy metal content in soil also increases the uptake of heavy metals by plants depending upon the soil type, plant growth stages and plant species [9]. The most important sources of heavy metals in the environment are the anthropogenic activities such as mining, smelting procedures, steel and iron industry, chemical industry, traffic, agriculture as well as domestic activities [10]. Chemical and metallurgical industries are the most important sources of heavy metals in soils [11]. The presence of heavy metals in soil can affect thewildlife, plant growth etc [12]. These heavy metals may adversely affect soil ecology, agricultural production or product quality, and ground water quality, and will ultimately harm to health of living organism by food chain. Therefore, the determination of free metal ion concentrations in soil solution becomes important. The free metal ion concentration not only depends on the total metal content in soils, but also on the metal species that exist in the soil [13]. Pollution of heavy metals in aquatic environment is a worldwide problem and currently it has reached an alarming rate. There are various sources of heavy metals; some originates from anthropogenic activities like draining of sewerage, dumping of Hospital wastes and recreational activities. Conversely, metals also occur in small amounts naturally and may enter into aquatic system through leaching of rocks, airborne dust, forest fires and vegetation. As heavy metals cannot be degraded, they are continuously being deposited and incorporated in water, thus causing pollution in water bodies. The presence of heavy metals in the water may have a profound effect on the microalgae which constitute the main food source for bivalve mollusks in all their growth stages, zooplankton (rotifers, copepods, and brine shrimps) and for larval stages of some crustacean and fish species. Moreover, bio-concentration and magnification could lead to high toxicity of these metals in organisms, even when the exposure level is low. Under such conditions, the toxicity of a moderately toxic metal could be enhanced by synergism and fish population may decline. Apart from destabilizing the ecosystem, the accumulation of these toxic metals in aquatic food web is a threat to public health and thus their potential long term impact on ecosystem integrity cannot be ignored [14]. Pollution of fresh water bodies, especially the rivers is no longer within safe limits for human consumption as well as aquatic fauna. Disposal of sewage wastes into a large volume of water could reduce the biological oxygen demand to such a great level that the entire oxygen may be removed. This would cause the death of all aerobic species including fishes. These may be derived from inputs of suspended solids to which toxic substances are absorbed; such as soil particles in surface water run-off from fields treated with pesticides. Pesticides are useful tools in agriculture but their contribution to the gradual degradation of the aquatic ecosystem cannot be ignored [15].

METERIALS AND METHODS

Materials Used

Plastic bottles for the collection of water, polyethylene bags (white Santana leather bags) for soil and sediments collection, Hoe, Stainless steel knife, Spoon, Ruler, Sediment Sampler, Digestion flasks, Pyrex beakers and conical flask, measuring cylinder, pen , masking tape, makers, Mortar and pestle, sieve.

Equipment’s (Apparatus and instruments)

The major Equipment’s used are: Atomic Absorption Spectrophotometer (model AA0904M046), X-ray Fluorescence Spectrophotometer (EDXF Minipal 4030 with a computer interphase), Metler Analytical balance, pH meter, Thermometer, Conductivity meter, Dissolved Oxygen meter, and heating mantle.

Study Area

The Kilange Streams (River) catchment covers an area of 4955 km^2encompassing parts of Fufore,Song, Gombi, and Hong, Local Government Areas of Adamawa state, Nigeria. It is located between latitudes 9° 23´ 26’’ N to 10° 19´ 00’’ N and longitudes 12° 15´ 00’ E to 13° 17´ 25’’ as shown in Figure 1 below. This research work were carried out in some selected farmlands of villages along river (Streams) Kilange in four (4) local government areas of Adamawa state.

Sampling and Sample preparation

Samples collection, treatment and preservation

The Sampling and preservation of samples were carried out as prescribed by APHA method [16]. In the field, soil, sediment and water were collected fromeight different locations (Farmlands) along Kilange stream in Adamawa state (Wuro-bokki, Wuro-yolde,Geleng, Muleng, Guriki,Wuro Alhaji, Zhyidinyi, and Dhirwachilla)sampling plots as shown in Figure 1below, Between (January and March 2020), for Dry season in each plot, and from (July and September 2020) for Wet Season in each plot. Soil samples from the study areas site were randomly sampled and bulked together to form a composite sample by using spade and hoe. In all cases, soil samples were put in clean plastic bags and transported to the laboratory. Soil samples were air-dried, ground into a fine powder using ceramic mortar and pistil and pass through 2mm mesh sieve. The samples were stored in polyethylene zip -type bags and label for further analysis. Soil samples were analyzed for heavy metals. Sediment samples from Kilange Stream areas were collected randomly using a plastic hand-trowel by scooping the top layer sediments. About 1 kg of the sediments samples was collected at each point, store in polyethylene bags, labeled and transport to the laboratory. Sediments samples were air-dried, crushed, ground into fine powder by using mortar and pistil, which pass through 2mm mesh sieve. The samples were stored in polyethylene zip -type bags and label for further analysis. Sediments samples were analyzed for heavy metals. Water samples were collected in plastic containers, and the containers were cleaned by washing in non-ionic detergent, rinsed with tap water and later will be soaked in 10% HNO_3 for 24 hours and finally rinsed with deionized water prior to usage. At each sampling point, water samples were collected in triplicate. The water samples were mixed in a clean plastic bucket and a representative sample of one liter was transferred into a clean polyethylene sample bottles filled to the brim. The samples were labeled and transport to the

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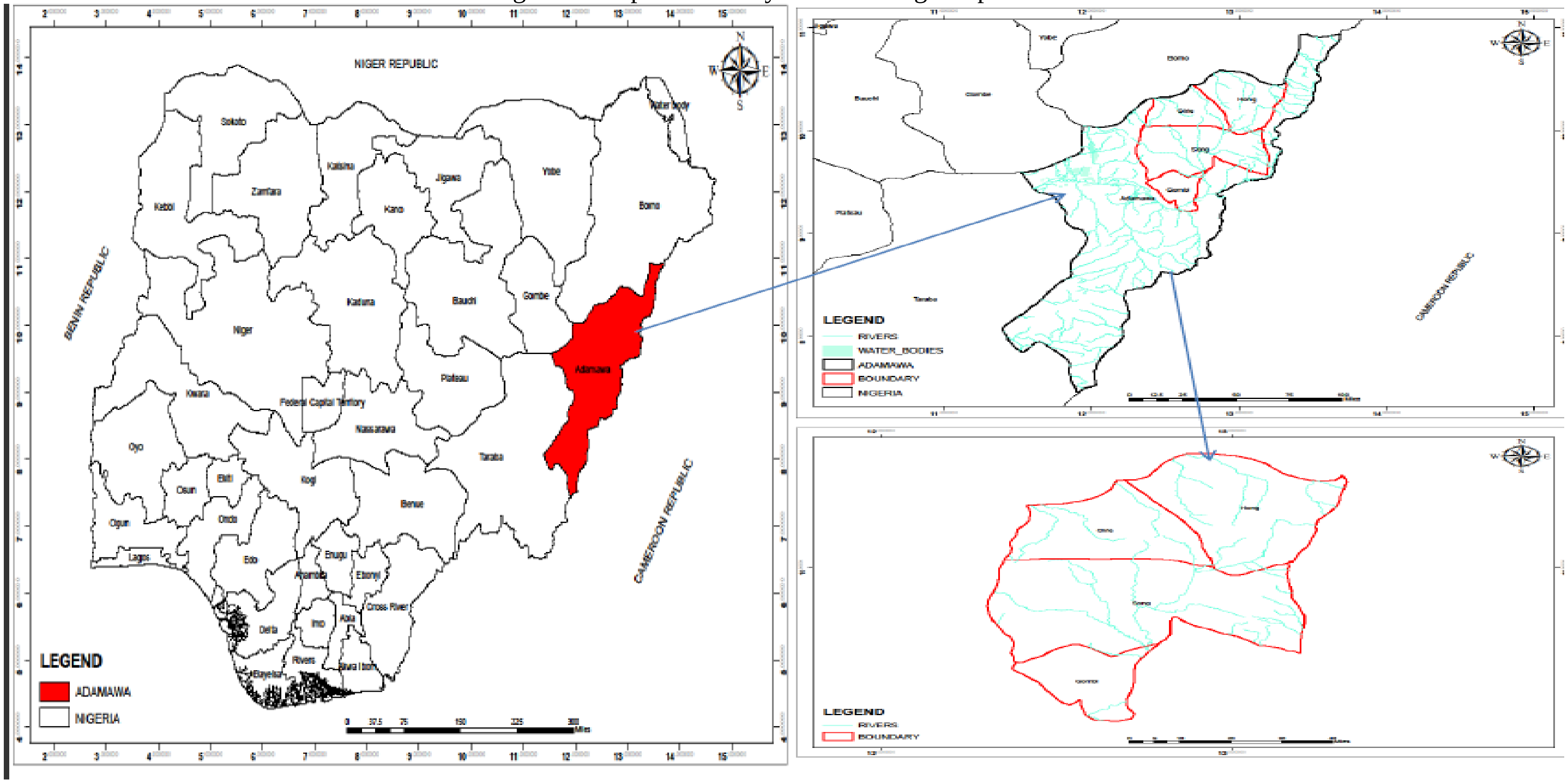
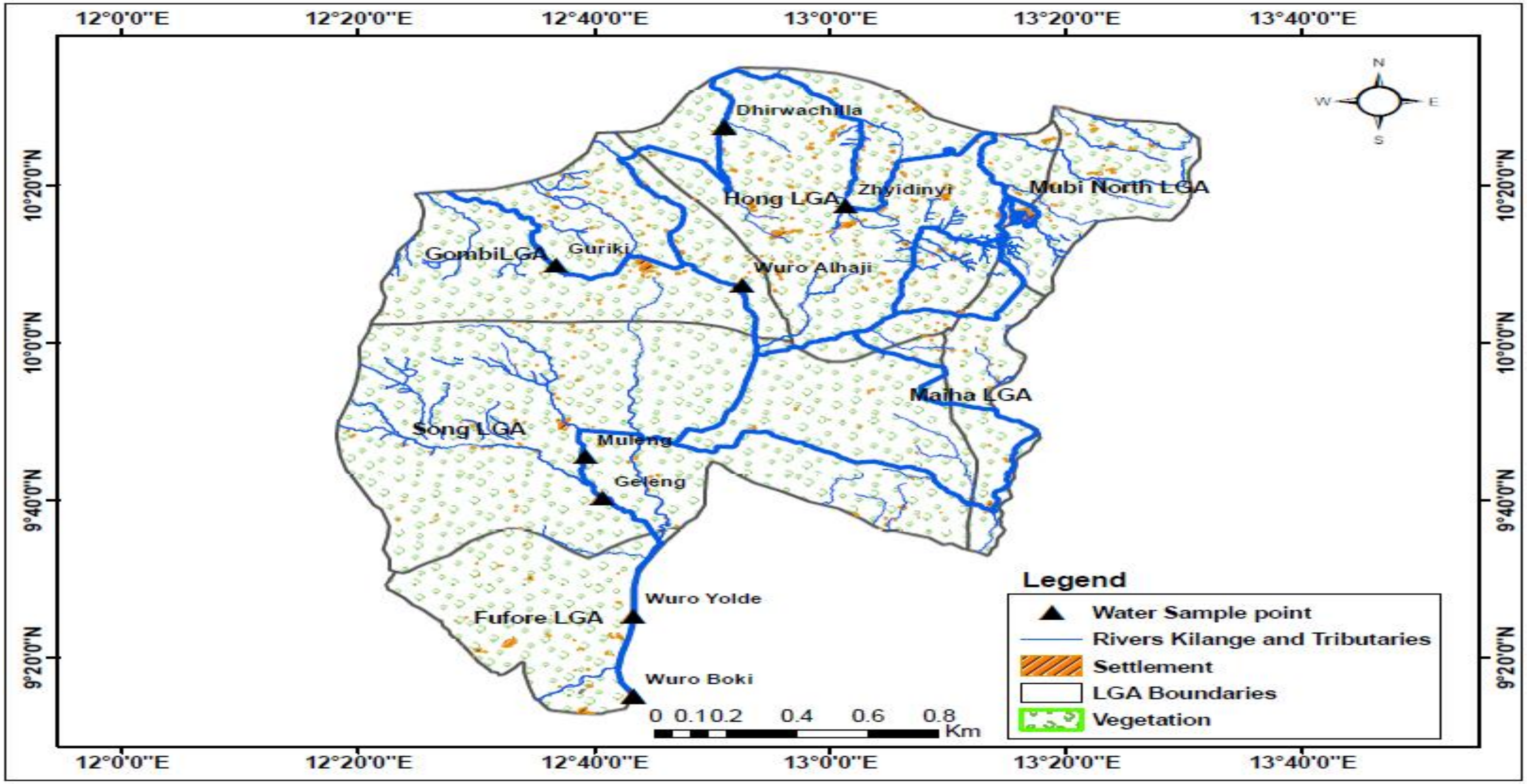
laboratory, store in the refrigerator at 4°C prior to analysis [17].

Figure 1: Map of the study area showing sample location

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Hong LGA
Zhyidinyi
Mubi North LGA
GombiLGA
Guriki
Wuro Alhaji
Maiha LGA
Song LGA
Muleng
Geleng
Wuro Yolde
Fufore LGA
Wuro Boki
0 0.1 0.2 0.4 0.6 0.8
Km
Legend
Water Sample point
Rivers Kilange and Tributaries
Settlement
LGA Boundaries
Vegetation

Preparation of Soil and Sediment Sample for Heavy Metal Determination

Soil and Sediment samples was air dried in the laboratory, any crumbs found in the soil and sediment was removed and mixed uniformly becoming, pulverized and quartering. Soil and Sediments was sieved through a 2 mm sieve to remove coarse particles.The samples were stored in polyethylene zip -type bags and label for further analysis. Sediments samples were analyzed for heavy metals using XRF Machine.

Digestion of Water Sample for Heavy Metal Determination

Water samples was digested as follows: 100 $cm^3$of the sample was transferred into a beaker and 5 mL concentrated HNO_3 were added. The beaker with the content were placed on a hot plate and evaporated down to about 20mL. The beaker was cooled and another 5 ml concentrated HNO_3were added. The beaker was covered with a watch glass and returned to the hot plate. The heating was continue, and then small portion of HNO_3 was added until the solutions appear light colored and clear. The beaker and watch glass were washed with distilled water and the sample filtered to remove some insoluble materials that could clog the atomizer. The volume was adjusted to 100 cm^3 with distilled water [18].

RESULTS AND DISCUSSION

Heavy Metals Concentration in Soil

Results for heavy metal compositions of soil, sediments, and water were presented on Tables 1-3.The concentration of heavy metals (mg/kg) in soil samples collected are presented in Table 1. The Heavy metal concentration in Soil samples recorded differed significantly (F-test, $P < 0.05$) as shown in tables along the locations. The content of heavy metals in the soils of the observation plots, which are most exposed to anthropogenic impact, varied in the following ranges. Lead is ranked as one of the most toxic heavy metals affecting man, animal and plant, which has been used by mankind for several years because of its wide variety of applications [19]. Lead is found in large amount in many electronic devices, lead acid battery extensively used in car batteries which can end up in soil through corrosion. The concentration of lead in all the investigated soil samples were found to be below detection limits. The critical concentration of Pb set by [20] is 300 mg/kg. The kidney, and to a lesser extent the lungs, are the critical organs in a long-term occupational or environmental exposure to cadmium. Cadmium (Cd) affects the functioning of kidneys and bones and may cause cancer. Accumulation of Cd in agricultural soils over time is induced by human activities [21]. Such activities include, excessive application of phosphate fertilizers, domestic and industrial effluents, waste water and pesticides, from traffic emission and tear and wear of alloyed parts of vehicles [8].The concentration of Cd in the soils from various sites studied were recorded. These values were all below detection limits. The permissible limit in soil set by [22] is 3.0- 5.0 mg/kg. Chromium is one of the less common elements and does not occur naturally in elemental form, but only in compounds. Major sources of Chromium contamination include releases from electroplating processes and the disposal of Cr containing wastes [23]. Chromium is widely used in metallurgy, electroplating, and in the manufacturing of paints, pigments, preservatives, pulp and papers among others. The introduction of Chromium into the environment is often through sewage and fertilizers. Hexavalent Chromium compounds including chromates of Ca, Zn, Sr, and Pb are highly soluble in water, toxic and carcinogenic [24]. Furthermore, compounds of Chromium have been associated with slow healing ulcers. It has also been reported that Chromate compounds can destroy DNA in cells [25]. Chromium (Cr) plays a vital role in the metabolism of cholesterol, fat, and glucose. Its deficiency causes hyperglycemia, elevated body fat, and decreased sperm count, while at high concentration it is toxic and carcinogenic [25]. Chromium (Cr) was only detected in Muleng and Guriki during dry season with a mean value of 1.110±0.01 and 2.30±0.01 mg/kgrespectively, while all other samples were recorded below detection limits. The WHO recommended safe limits for Cr (hexavalent) in wastewater and soils used for agriculture are 0.05

and 0.1 ppm respectively. Manganese is a very essential trace elements for plants and animals growth. Its deficiency produces severe skeletal and reproductive abnormalities in mammals. High concentration of manganese (Mn) causes hazardous effects on lungs and brains of humans [26]. Mn was one of the heavy metal detected in all the soil samples investigated from the areas around the Kilange River. It has a mean concentration ranging from 0.00 mg/kg-2.40 mg/kg, with the lowest values of 0.00 mg/kg at Muleng during dry season and the highest value of 2.40 mg/kg at Dirwachilla during wet season. These maybe due to the presence of high amount of agricultural and domestics wastes which had a higher contents of heavy metals. Mean concentration of Mn in soils from the areas under study were within the globally accepted range for Mn and this is in consonance with previous studies. The mean concentration from each sampling locations is within the acceptable limit for Agricultural soils (20-1000 mg/kg) as provided by [22]. Nickel is a silver - colored metal used in making stainless steel, electronics, and coins among other uses. Nickel has been considered to be an essential trace element for human and animal health [26]. Globally, the release of Ni to the environment is estimated to vary from 150, 000 to 180 000 metric tons per year [27]. Exposure of Ni to humans is through food, air and water. Previous study has shown that ingestion of dust contaminated with Nickel was the main exposure pathway of the heavy metal by local residents when compared to inhalation and dermal pathway [28]. The disadvantageous effects of nickel on human health may include dermatitis, allergy, organ diseases, and cancer of the respiratory system [29]. The recommended safe limits by WHO for Ni agricultural soils is 0.05 mg/Kg. In all the collected soil samples no concentration of nickel was detected. Mercury is a ubiquitous environmental toxin that produces a wide range of adverse health effects in humans. The most common natural forms of mercury found in the environment are metallic mercury, mercuric sulfide (cinnabar ore, mercuric chloride, and methyl mercury). Each of them has its own profile of toxicity [30]. Mercury can enter and accumulate in the food chain. The form of mercury that accumulates in the food chain is methyl mercury. Symptoms of mercury poisoning include permanent damage to the brain and kidneys, personality changes (irritability, shyness, and nervousness), tremors, changes in vision, deafness, muscle incoordination, loss of sensation, and difficulties with memory [31]. In all the soil sample collected, the concentration of Hg were recorded below detection limits. The permissible limit set by [22] is 2.00 mg/kg. Mercury is an environmental pollutant which induces severe alteration in the body tissue and causes a wide range of adverse health effects. Arsenic is the most common cause of acute metal poisoning in adults and is No 1 on the ATSDR's (Agency for Toxic Substances and Disease Registry in Atlanta Georgia) ''Top 20 list''. Target organs are the blood, kidneys and the central nervous, digestive and skin systems [32]. In all the soil sample collected, the concentration of As were recorded below detection limits. The concentration of arsenic in the soil samples analyzed were below detection limits. The permissible limit of As by [22] is 20 mg/kg. Selenium compounds are distributed throughout the environment as a result of human activities (industrial and agricultural uses) and natural processes (weathering of minerals, erosion of soils and volcanic activity). Generally soil contains selenium at the ppm level and it is assumed that selenium occurs in inorganic (-II, 0, IV, VI) and organic forms in soil [33]. The concentrations of selenium recorded in study areas were below detection limits. The recommended limit in soils set by [22] 10 mg/kg.

Table 1: Heavy Metals Concentrations in mg/kg of Soil Sample along River Kilange Adamawa State

Site	Seasons	Mn	Pb	Cr	Cd	Ni	Zn	As	Se	Hg	Ag
Wuro-Bokki	Dry	0.13±0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Wet	0.15±0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
Wuro-Yolde	Dry	0.21±0.12	ND	ND	ND	ND	6.76±.06	ND	ND	ND	ND
	Wet	0.22±0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
Geleng	Dry	0.15±0.04	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Wet	0.90±0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
Muleng	Dry	0.00±0.00	ND	1.110±0.0	ND	ND	8.32±0.0	ND	ND	ND	ND
	Wet	0.110±0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Guriki	Dry	0.130±0.1	ND	2.30±0.01	ND	ND	ND	ND	ND	ND	ND
	Wet	0.130±0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND
Wuro Alhaji	Dry	0.10±0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Wet	0.110±0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zyhdlinyi	Dry	0.12±0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Wet	0.160±0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dirwachilla	Dry	1.8±0.03	ND	ND	ND	ND	1.05±0.0	ND	ND	ND	ND
	Wet	2.40±0.20	ND	ND	ND	ND	ND	ND	ND	ND	ND
Standard Unit		mg/kg	mg/k	mg/kg	mg/kg	mg/k	mg/kg	mg/k	mg/k	mg/k	mg/kg
Range		0.00-2.40	-	0.00-1110	-	-	0-8320	-	-	-	-
Per. Value: WHO (2008)		20-1000	0.03	0.05-0.1	3.0-	0.05	0.02	0.02	0.01	0.05	-

Mean ± Standard Deviation within a column are not significantly different at P > 0.05 according to Duncan Multiple Range Test

The concentrations of heavy metals in sediment at different location during wet and dry seasons, along river Kilange are presented in Table 2. The concentrations of Pb ranged from 0.600±0.1 to 1.240±0.0 mg/kg, Pb was only found in Wuro Alhaji, Zyhdinyi and Dirwachilla all during dry season, but it was not detected in all the other samples. Cr was only detected in Guriki during dry season with a mean concentration of 0.870±0.02 mg/kg but it was not detected in all the other samples. Similarly, Cd was only detected in Wuro-Yolde during dry season with a mean concentrationof 0.530±0.1 mg/kg. Cd was not detected in all the other samples. However, Ni, As, Se, Hg and Ag were recorded below the detection limits in all the locations both during dry and wet seasons.The mean concentrations of Zn ranged from 0.640 to 17.740 mg/kg. Concentration of zinc was only found in Geleng, Guriki, Wuro Alhaji and Dirwachilla all during dry seasons with a mean concentration of 17.740±0.02, 0.640±0.01, and 0.840±0.0 mg/kg respectively. Lead is also leached together with Cd by the weathering of heaps of rock materials dug during the mining operations by acids. It is also contained in some farm chemicals as impurity where it finds its way eventually into stream sediment as the sink for this and other metals. The higher concentration of these metals in Wuro Alhaji, Zyhdinyi, and Dirwachilla during dry season might be as a result of the previous use of chemicals fertilizers thereby turning out into the water and stream bed more of the toxic heavy metals. The United State Environmental Protection Agency (USEPA) has recommended a safe limit of 40 μg/g [34]. Pb for the toxic metal in sediment above which such sediments body becomes dangerous for benthic organisms. Observably, all sediments samples collected for both seasons were above the recommended safety limit. Lead was only detected in Wuro Alhaji, Zyhdinyi, and Dirwachilla during dry season with a mean concentration of 0.600±0.01, 1.240±0.01, 0.6600±0.01 respectively. While all other samples were recorded below detection limits. While these Pb concentrations were above the recommended limits of 0.03mg/kg by WHO, the metal is toxic even at low levels as it is non degradable and has a tendency to bio accumulate to toxic levels. Some of the effects of Pb poisoning include deficiency in cognitive function due to destruction of the central nervous system, abdominal pain and discomfort, formation of weak bones as Pb replaces calcium and causes anemia due to reduction of enzymes concerned with synthesis of red blood cells [35]. The kidney, and to a lesser extent the lungs, are the critical organs in a longterm occupational or environmental exposure to cadmium. Cd affects the functioning of kidneys and bones and may cause cancer. Accumulation of Cd in agricultural soils over time is induced by human activities [36]. Such activities include, excessive application of phosphate fertilizers, domestic and industrial effluents, waste water and pesticides, from traffic emission and tear and wear of alloyed parts of vehicles [37]. Cadmium was only detected in Wuro Yolde during dry season with a mean concentration of 0.530±0.01, while all other samples were recorded below detection limits. While the levels of Cd in sediment sampled detected from Wuro-Yolde study area exceed this recommended limit, the element is toxic and ingestion can rapidly cause feelings of nausea, vomiting, abdominal cramp and headache, as well as diarrhea and shock. Comparable concentrations of Cd in sediments with the current study have been recorded from a number of rivers. Cadmium concentration range of 0.4-0.7 mg/kg of sediments from River Nile and 0.072 mg/kg from Wadi Hanifah River have been recorded [38]. These concentrations were attributed to variations in mud present and increase in Cd metal rich urban effluents draining into River Nile (Alaa and Osman, 2010). Heavy metal contamination in sediments can affect the water quality and bioaccumulation of metals in aquatic organisms, resulting in potential long-term implication on human health and ecosystem [39]. Chromium (Cr) plays a vital role in the metabolism of cholesterol, fat, and glucose. Its deficiency causes hyperglycemia, elevated body fat, and decreased sperm count, while at high concentration it is toxic and carcinogenic (Oladebeye, 2017). Cr is very harmful to living organisms. The hexavalent form of Cr is the most toxic. The maximum concentration of Cr found in sediments in Guriki during dry season with a mean value of 0.850±0.01, while all other samples were recorded below detection limits. Though the levels were below the recommended limit by FAO/WHO of 37.5mg/kg DW for Cr in sediment, increased levels can affect the water quality and bioaccumulation of metals in aquatic organisms, resulting in potential long-term implication on human health and ecosystem [40]. Sediments act as the most important reservoir or sink of metals and other pollutants in the aquatic environment [41]. Heavy metal contamination in sediments can affect the water quality and bioaccumulation of metals in aquatic organisms, resulting in potential long-term implication on human health and ecosystem [42]. Sediments from Wadi Hanifah contained very high significant amounts of chromium when compared with their concentration in water (0.006mg/kg) and fish (0.386mg/kg) [43]. A constant monitoring program to assess the impact of Cr in the ecosystem was therefore recommended. Manganese (Mn) plays several roles in physiological processes in living organisms, including humans. It is a major component of enzymes. In domestic water, Mn can constitute a nuisance if present in a high concentration with a characteristic metallic taste and staining properties [44]. Manganese was one of the heavy metal detected in all the sediments samples investigated from the areas around the Kilange River. It has a mean concentration ranging from 0.08 mg/kg – 0.25 mg/kg, with the lowest values of 0.08 mg/kg at Muleng during dry season and the highest value of 0.25 mg/kg at Geleng during wet season. The levels of Mn determined in this study is below those reported by [45]. Though the limit of Mn in sediments is not documented, in larger amounts, and apparently with far greater activity by inhalation, Mn can cause a poisoning syndrome in mammals, with neurological damage which is sometimes irreversible [45]. Victims of Mn poisoning suffer from cerebella dysfunctions as well as awkward high-stepping gait [46]. Mn concentrations in the range of 0.24–0.35 mg/L can lead to memory lapses in children. Similar findings have also reported decreased concentration and attentiveness in classes by children who drink water with a high Mn concentration [47]. Neurotoxicity has been implicated for adults over 50 years who drink Mn-rich water [48]. Mn usually affects the brain and the central nervous system, causing impaired neurological and neuromuscular control, among other symptoms [49].Nickel (Ni) is a widespread metal/metalloid in the environment. Its sources can be electroplating, non-ferrous metal, paints and porcelain enamelling. The effects of Ni in the human organism are cardiovascular diseases, chest pain, dermatitis, dizziness, dry cough and shortness of breath, headache, kidney diseases, lung and nasal cancer and nausea [50]. However, all the sediments collected, the concentration of Ni were recorded below detection limits. Though Ni limits have not been documented for sediments, Ni compounds, except for metallic Ni, have been classified as carcinogenic to humans. Among the known health-related effects of Ni are skin allergies, lung fibrosis, variable degrees of kidney and cardiovascular system poisoning and stimulation of neoplastic transformation [51]. It was therefore concluded that constant monitoring of levels of contamination was necessary to assess the impact of heavy Metals in the aquatic system. Mercury (Ag) is one of the most toxic heavy metals that can cause pollution. This is essentially due to the gas phase which will allow the different transfers in space and with matter. Batteries, coal combustion, geothermal activities, mining, paint industries, paper industry, volcanic eruption and weathering of rocks are sources of Hg. They can have some effects on human such as: ataxia, attention deficit, blindness, deafness, decrease rate of fertility, dementia, dizziness, dysphasia, gastrointestinal irritation, gingivitis, kidney problem, and loss of memory, pulmonary edema, reduced immunity and sclerosis [52]. In the current study, it is reported that the concentrations of Hg (mg/kg) were recorded below detection limits in the sediments from all the study areas. Arsenic (As) is one of the most important heavy metals causing disquiet from both ecological and individual health stand points. It has a semi metallic property, is prominently toxic and carcinogenic, and is extensively available in the form of oxides or sulfides or as a salt of iron, sodium, calcium, copper, etc. Arsenic is the twentieth most abundant element on earth and its inorganic forms such as arsenite and arsenate compounds are lethal to the environment and living creatures. Humans may encounter arsenic by natural means, industrial source, or from unintended source [53]. Arsenic is a proto plastic poison since it affects primarily the sulphydryl group of cells causing malfunctioning of cell respiration, cell enzymes and mitosis [54]. The concentration of arsenic in the sediments analyzed were below detection limits. Selenium (Se) is a trace element that is widely distributed in aquatic and terrestrial systems. Selenium bio- geochemistry is complex because selenium occurs in several inorganic and organic forms and many physical and biological processes affect its concentration, mobility, and distribution. Because the range of concentration that are beneficial to plants and animals is small, understanding the sources and transport mechanisms of selenium is important. Selenium in sediments can be released to water through oxidation enhanced by plant roots and microorganisms or through physical agitation of sediments by wind, currents, or the feeding activities of benthic invertebrates, fish, and water birds. Bioaccumulation may occur easily because selenium is an essential micronutrient and is chemically similar to sulfur. The concentrations of selenium recorded in study areas were below detection.

Heavy Metals Concentration in Wateralong River Kilange, Adamawa State

Metal concentrations of water are presented in Table 3 The Pb mean concentration value was only found in Guriki during dry season with a mean concentration of 0.04±0.001 mg/l. the concentration of Cr ranged from 0.00±0.00 to 0.04±0.001 mg/L while that of Ni ranged from 0.07±0.001 to 0.10±0.001. As revealed in the results, it is evident that the concentration of the heavy metals in the water samples was relatively low. A number of the metals (Co, Cd, As and Hg) were present in non-detectable quantities in water samples, similar to their concentration levels in soil and sediments samples during both dry and wet seasons. This could be attributed to strong variations of flow rate, pollutant input and transport as well as sedimentation of the metals. The presence of Pb, Cr and Ni could be attributed to the presence of abandoned parts of heavy pumping machines and equipment which littered the surroundings of the rivers, mainly within the vicinity of the company. Concentrations of non-essential element Pb was only detected in the water samples from Guriki during dry season with a mean value of 0.04±0.001mg/kg. Lead value found Guriki to be higher than 0.01 mg/l, recommended limit of Pb in drinking water [55]. This makes the water unsuitable for human consumption as Pb is known to be toxic even at low levels with resultant ill-health effects as chronic exposure has been linked to growth retardation in children [56]. Lead is a hazardous component; it is injurious even in minor quantities. Lead component comes in the Human body majorly found in water and food. It can be gasped in powder form of lead in paints, or excess gases from leaded petroleum products. It is originated in minor quantities in several water bodies & food, particularly fish, which remain seriously focus to industrialized toxic waste. Approximately old households might water pipes consume lead, which can then pollute intake water. Contact to lead is growing above period. Extreme level of lead absorptions in the human body can cause death or perpetual harm to the brain, central nervous system and kidneys [57]. The Nigerian regulating body has stipulated a safe limit of 0.01 mg/L for water meant for domestic applications to which most of the waters in the study area are been used. Other possible anthropogenic sources of the metal in stream water are burning of fossil fuel and contribution from road side dust [58]. Studies of water from Ikpoba River, and Nairobi River recorded mean Pb levels of 0.035mg/l and 0.1 mg/l that were comparable to the current studies but above the recommended limit of 0.01mg/l of Pb in drinking water [59]. Based on these results it was recommended that an evaluation program be set up to constantly monitor the levels of heavy metals in order to protect people using the river water against possible contamination*Cadmium*(Cd) is known to cause damage to all types of body cells by increasing their permeability and allowing other heavy metals enter into it. Exposure to this metal causes symptoms similar to food poisoning. Accumulation of this metal in man results in the itai-itai disease, which causes problems in calcium metabolism, followed by decalcification, rheumatism, neuralgia and cardiovascular problems. High concentrations accumulated in organisms destroy the testicular tissue and red blood cells and can lead to mutagenic and teratogenic effects [60]. A safe limit of 0.003 mg/l has been recommended for Cd by the Nigerian standard for drinking water quality (NSDWQ, 2007). However, this limit was Cd was found below the detection limits in all water samples in both the dry and wet season in the study area, which makes the water safe with respect to Cd contamination [45]. Excess Chromium becomes toxic, as a result of its exposure through inhalation and ingestion, producing toxicity in the lungs and stomach, because it is absorbed through cellular membranes and then infiltrates the interior of the cells. Dermal exposure to chromic acid causes skin damage, allowing rapid absorption of hexavalent chromium ions and leading to a potential acute chromium intoxication. Cr (VI) is considered a powerful carcinogen [47]. The mean concentration of Cr was detected in all the water samples within the range of 0.01 to 0.04 during both wet and dry seasons. These Cr mean levels were lower than the recommended limit of 0.05 mg/l for Cr in drinking water [49]. This means that consumption of water from the selected locations is not safe since hexavalent Cr is very toxic and mutagenic when inhaled and is a known human carcinogen, where long term exposure can cause damage to liver, kidney circulatory and nerve tissues, as well as skin irritation[55]

Table 2:Heavy Metals Concentrations in mg/L of Water Sample along River Kilange Adamawa State

Site	Seasons	Fe	Mn	Pb	Cr	Ni	Zn	Co	As	Cd	Hg
Wuro-Bokki	Dry	1.06±0.001	0.32±0.001	ND	0.0±0.0012	0.07±0.001	0.12±0.001	ND	ND	ND	ND
	Wet	1.55±0.001	0.33±0.001	ND	0.03±0.001	0.07±0.001	0.002±0.001	ND	ND	ND	ND
Wuro-Yolde	Dry	0.14±0.001	10.89±0.001	ND	0.03±0.001	0.09±0.001	0.00±0.00	ND	ND	ND	ND
	Wet	0.07±0.001	10.68±0.001	ND	0.02±0.001	0.08±0.001	0.19±0.001	ND	ND	ND	ND
Geleng	Dry	0.23±0.001	0.00±0.00	ND	0.02±0.001	0.08±0.001	0.00±0.00	ND	ND	ND	ND
	Wet	4.61±0.01	0.26±0.001	ND	0.02±0.001	0.08±0.001	0.06±0.001	ND	ND	ND	ND
Muleng	Dry	0.05±0.00	ND	ND	0.03±0.00	0.08±0.00	0.00±0.00	ND	ND	ND	ND
	Wet	0.001±0.00	ND	ND	0.03±0.001	0.09±0.001	0.007±0.001	ND	ND	ND	ND
Guriki	Dry	0.80±0.001	ND	0.04±0.001	0.00±0.00	0.10±0.001	0.02±0.001	ND	ND	ND	ND
	Wet	0.91±0.001	ND	ND	0.02±0.001	0.08±0.001	0.05±0.001	ND	ND	ND	ND
Wuro Alhaji	Dry	3.99±0.001	ND	ND	0.03±0.001	0.08±0.001	0.05±0.001	ND	ND	ND	ND
	Wet	1.66±0.001	ND	ND	0.03±0.001	0.07±0.001	0.05±0.001	ND	ND	ND	ND
Zyhdinyi	Dry	2.41±0.01	ND	ND	0.04±0.001	0.09±0.001	0.04±0.001	ND	ND	ND	ND
	Wet	0.78±0.001	ND	ND	0.02±0.001	0.07±0.001	0.02±0.001	ND	ND	ND	ND
Dirwachilla	Dry	0.89±0.001	ND	ND	0.01±0.001	0.07±0.001	0.04±0.001	ND	ND	ND	ND
	Wet	0.26±0.001	ND	ND	0.011±0.001	0.08±0.001	0.00±0.00	ND	ND	ND	ND
P-value		P <0.05	P <0.05	P <0.05	P <0.05	P <0.05	P <0.05	-	-	-	-
Range		0.001-4.61	0.00-10.89	0.00-0.04	0.00-0.04	0.07-0.10	0.00-0.19				

Mean ± Standard Deviation within a column are not significantly different at P > 0.05 according to Duncan Multiple Range Test

ND = Not Detection

The deleterious effects on public health regarding the elevated concentrations of Ni were caused mainly by inhalation through the respiratory tract and ingestion of contaminated water, containing ultrafine particles of nickel metal, at one dose. This can normally result in greater inflammatory response, probably because the extremely small size of the particle and the large corresponding surface area can change several mechanisms of the organism, e.g. inhibit phagocytosis, increase oxidative stress, and increase inflammation in the lung epithelium, allowing the ultrafine particles to diffuse more rapidly within the lung interstitium and increasing the risk of lung cancer [56]. Mean concentration of Ni were found to be ranged from 0.07 to 0.1mg/kg. The concentrations within the WHO accepted limits for Ni is 0.02mg/kg or less. Nickel metal from water could be a contributing source to the levels in irrigated vegetables which require constant monitoring as elevated levels have been reported to cause sub-lethal effects [60]. Mercury is toxic and has no known function in human biochemistry and physiology. Inorganic forms of mercury cause spontaneous abortion, congenital malformation and gastrointestinal disorders (like corrosive esophagitis and hematochezia). Mercury cause spontaneous abortion, congenital malformation and gastrointestinal disorders. However, Hg were found below the detection limits in all the water sample during both dry and wet seasons. Arsenic is often found as a by-product of both acid mine drainage and of neutral pH leaching of mining wastes from many precious and base metal ore deposits. Arsenic minerals associated with gold mining include arsenopyrite (FeS_2, , FeAsS) and tennantite [(Cu, Fe, Zn,) As4S] [45]. Oxidation of these minerals has been known to impact on the environment; they act as sources of sulphate acidity and heavy metals contamination of streams and groundwater [46]. Exposure to As has been linked to still births and defects; it can move to the fetus from the placenta and is transferable from mother to child during breastfeeding. Other important sources of arsenic exposure include coal burning, use of arsenic in pesticides, consumption of contaminated foodstuffs and exposure to wood preserving arsenicals. Water for domestic applications has permissible limit of 0.01 mg/L as Recommended by environmental regulatory bodies in Nigeria [35] as well as the World Health Organization [40]. The water samples from eight villages in the study areas during both dry and wet seasons were not contaminated with As. As a component of cobalamin (vitamin B12), cobalt is essential in the body; the cobalt has been identified in most tissues of the body, with the highest concentrations found in the liver [43]. Cobalt enters the air through burning of oil and cobalt compounds that are used as colorants in glass, ceramics, and paints, as catalysts, and as paint driers. Cobalt compounds are also used as trace element additives in agriculture and medicine [47]. After it enters the air cobalt is associated with particles which will settle to the ground within few days. Some of the compounds may then settle in water, food and drinking water and these are the largest sources of exposure to the general population [48]. The mean concentration of Co was only detected in the water sample from Geleng during dry season with a mean concentration of 0.09 mg/kg. The mean concentration of Mn detected from all the water samples ranged from 0.26 to 10.89 mg/l during both wet and dry seasons. In all the sampling stations, Mn was found to be higher than 0.4 mg/l the recommended limit for Mn in drinking water [50]. This means that the water was polluted and unsuitable for human use as far as Mn is concerned. This exposes the population using water to a threat of Mn related problems like neurological damage and motor disturbances.

CONCLUSION

The main objective of this research work was to assess is to explore the levels of some essential elements and heavy metals in soil, sediment, water and some vegetables grown along the river kilange. A total of 16 soil, sediments and water samples were collected and analyzed heavy metals (Ca, K, Na, Mg, Zn, Cu, Mn, Fe, Cr, Ni, Cd, Pb, Hg, Se, Ag, and as) parameters using standard procedures. Results of heavy metal analysis of soil, sediment and water obtained from eight (8) sampling sites along the kilange in adamawa state during the wet and dry seasons were found to contain all the analysed heavy metals (except As, Hg, Se, And Ag) at different levels. Concentrations of Pb, Ni, Cd, As, Se, Hg And Ag were not detected in soil samples, Ni, As, Se, Hg And Ag were not detected in sediments and Co, As, Cd And Hg in water samples obtained from eight sampling sites along river Kilange during the wet and dry seasonshowever, in sample of sediments Pb was only detected in Wuro Alhaji, Zyhdinyi, Dirwachilla during dry season with a mean concentration of 0.600±0.01, 1.240±0.01, 0.6600±0.01mg/kg, respectively, cadmium was only detected in wuro yolde during dry season with a mean concentration of 0.530±0.01mg/kg, andCr found in Guriki during dry season with a mean value of 0.850±0.01mg/kg, They were found to have exceeded the who recommended limits. Mn was one of the heavy metal detected in all the sediments samples investigated from the areas around the KilangeRiver. It has a mean concentration ranging from 0.08 mg/kg – 0.25 mg/kg, with the lowest values of 0.08 mg/kg at Muleng during dry season and the highest value of 0.25 mg/kg at Geleng during wet season. Water was also found to contain different levels of the heavy metals. The mean levels of Pb in was only detected in the water samples from Guriki during dry season with a mean value of 0.04±0.001mg/kg, Cr was detected in all the water samples within the range of 0.01 to 0.04mg/kg, during both wet and dry seasons and concentration of Ni were found to be ranged from 0.07 to 0.1mg/kg in all the sampling sites during both dry and wet season. Mean levels of Pb, Cd and Cr featured in soil, sediments and water samples with concentrations above the recommended limits by WHO. The concentration of heavymetals from three different samples i.e. Soil, Sediments and Water from Wuro-Bokki, Wuro-Yolde, Geleng, Muleg, Guriki, Wuro – Alhaji, Zyhdinyi and Dirwachilla were determined. Our results indicate that there were differences in trace metal concentration in soil, sediment and water and between the sampling sites. Concentrations of non- essential metallic elements were higher in sediments and water samples than what we found in soil samples from all the locations. In the heavy metal analysis, only levels of Pb, Cd and Cr featured in soil, sediments and water samples with concentrations above the recommended limits by WHO. Our results indicate that river Kilange has significant basal contamination levels that do not reach those of clearly polluted areas. However, there is need therefore for continuous monitoring of pollution levels in the river.

Table 3: Heavy Metals Concentrations in mg/kg of Sediment Sample along River Kilange Adamawa State

Site	Seasons	Fe	Mn	Pb	Cr	Cd	Ni	As	Se	Hg	Ag
Wuro-Bokki	Dry	59.46±0.1222	0.17±0.01	ND	ND	ND	ND	ND	ND	ND	ND
	Wet	40.87±0.13	0.20±0.01	ND	ND	ND	ND	ND	ND	ND	ND
Wuro-Yolde	Dry	63.22±0.08	0.15±0.01	ND	ND	0.53±0.01	ND	ND	ND	ND	ND
	Wet	45.66±0.16	0.13±0.01	ND	ND	ND	ND	ND	ND	ND	ND
Geleng	Dry	49.75±0.15	0.16±0.01	ND	ND	ND	ND	ND	ND	ND	ND
	Wet	43.15±0.13	0.25±0.01	ND	ND	ND	ND	ND	ND	ND	ND
Muleng	Dry	66.10±0.06	0.08±0.01	ND	ND	ND	ND	ND	ND	ND	ND
	Wet	55.01±0.09	0.11±0.01	ND	ND	ND	ND	ND	ND	ND	ND
Guriki	Dry	65.98±0.07	0.19±0.02	ND	0.87±0.02	ND	ND	ND	ND	ND	ND
	Wet	50.51±0.07	0.20±0.01	ND	ND	ND	ND	ND	ND	ND	ND
Wuro Alhaji	Dry	79.60±0.09	0.19±0.02	0.60±0.1	ND	ND	ND	ND	ND	ND	ND
	Wet	62.01±0.04	0.22±0.01	ND	ND	ND	ND	ND	ND	ND	ND
Zyhdinyi	Dry	6.307±0.08	0.13±0.01	1.24±0.01	ND	ND	ND	ND	ND	ND	ND
	Wet	51.14±0.07	0.12±0.01	ND	ND	ND	ND	ND	ND	ND	ND
Dirwachilla	Dry	64.47±0.11	0.11±0.01	0.66±0.01	ND	ND	ND	ND	ND	ND	ND
	Wet	53.14±0.05	0.14±0.01	ND	ND	ND	ND	ND	N	ND	ND
Standard Unit		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Range		6.307-79.60	0.08-0.25	0.60-1.24	0.00-0.87	0.00-0.53	-	-	-	-	-
Per. Value: WHO (2008)		*0.3*	*0.5*	*0.003*	*0.05*	*0.0.03*	*0.05*	*0.02*	*0.01*	*0.01*	*0.02*

Mean ± Standard Deviation within a column are not significantly different at P > 0.05 according to Duncan Multiple Range Test
ND = Not Detected

Table 4: Heavy Metals Concentrations in mg/L of Water Sample along River Kilange Adamawa State

Site	Seasons	Fe	Mn	Pb	Cr	Ni	Zn	Co	As	Cd	Hg
Wuro-Bokki	Dry	1.06±0.001	0.32±0.001	ND	0.0±0.0012	0.07±0.001	0.12±0.001	ND	ND	ND	ND
	Wet	1.55±0.001	0.33±0.001	ND	0.03±0.001	0.07±0.001	0.002±0.001	ND	ND	ND	ND
Wuro-Yolde	Dry	0.14±0.001	10.89±0.001	ND	0.03±0.001	0.09±0.001	0.00±0.00	ND	ND	ND	ND
	Wet	0.07±0.001	10.68±0.001	ND	0.02±0.001	0.08±0.001	0.19±0.001	ND	ND	ND	ND
Geleng	Dry	0.23±0.001	0.00±0.00	ND	0.02±0.001	0.08±0.001	0.00±0.00	ND	ND	ND	ND
	Wet	4.61±0.01	0.26±0.001	ND	0.02±0.001	0.08±0.001	0.06±0.001	ND	ND	ND	ND
Muleng	Dry	0.05±0.00	ND	ND	0.03±0.00	0.08±0.00	0.00±0.00	ND	ND	ND	ND
	Wet	0.001±0.00	ND	ND	0.03±0.001	0.09±0.001	0.007±0.001	ND	ND	ND	ND
Guriki	Dry	0.80±0.001	ND	0.04±0.001	0.00±0.00	0.10±0.001	0.02±0.001	ND	ND	ND	ND
	Wet	0.91±0.001	ND	ND	0.02±0.001	0.08±0.001	0.05±0.001	ND	ND	ND	ND
Wuro Alhaji	Dry	3.99±0.001	ND	ND	0.03±0.001	0.08±0.001	0.05±0.001	ND	ND	ND	ND
	Wet	1.66±0.001	ND	ND	0.03±0.001	0.07±0.001	0.05±0.001	ND	ND	ND	ND
Zyhdinyi	Dry	2.41±0.01	ND	ND	0.04±0.001	0.09±0.001	0.04±0.001	ND	ND	ND	ND
	Wet	0.78±0.001	ND	ND	0.02±0.001	0.07±0.001	0.02±0.001	ND	ND	ND	ND
Dirwachilla	Dry	0.89±0.001	ND	ND	0.01±0.001	0.07±0.001	0.04±0.001	ND	ND	ND	ND
	Wet	0.26±0.001	ND	ND	0.011±0.001	0.08±0.001	0.00±0.00	ND	ND	ND	ND
P-value		$P < 0.05$	$P < 0.05$	$P < 0.05$	$P < 0.05$	$P < 0.05$	$P < 0.05$	-	-	-	-
Range		0.001-4.61	0.00-10.89	0.00-0.04	0.00-0.04	0.07-0.10	0.00-0.19				

Per. Value: WHO (2008)

Mean ± Standard Deviation within a column are not significantly different at P > 0.05 according to Duncan Multiple Range Test

ND = Not Detection

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