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Review Article

Critical Review of the Current Status of Soil Contamination in Kenya

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Abstract: The growth of economy in Kenya is an impressive factor for the development, and is considered as improving living standard of many. However, pollution goes in hand with growing population and economic activities. Soil contamination is rampart now days, but it is not taken as of more concern like water and air pollution. The main sources of soil contaminations are anthropogenic activities such as synthetic chemical products, mining and natural sources. This dissertation focuses on the review of current status of soil contamination in Kenya. Secondary data from various published papers were used to determine the most popular contaminants in the soil (Pb, Zn, Cu, Cd, Mn and Dioxin). This paper further examines two case studies on health impacts of contaminants, for instance lead poisoning in Nairobi city were carried on children age between 2 to 18 years who are living around Dandora dumpsite area. It was determined that number of them are suffering from ailments that might be attributed to contaminants. Finally, this study touches on environmental legal framework that governs the land in Kenya. It indicates that only laws to conserve the soil fertility are taken into account, but there are no specific laws to protect soil quality against contaminants.

Keywords: Soil Contamination, Health Implications, Heavy Metals, Most Popular Contaminants, Legal Framework, Kenya's Soil

1. Introduction

Kenya is located in the Central-Eastern Africa. It lies across the equator within latitudes 0.0236°S and 37.9062°E on the coast of Indian Ocean [1]. Kenya covers 582,646 km^2 and is divided into 47 counties with an approximately population of 46 million people [2]. Figure 1 below is a population density map of Kenya, and it shows that big towns have very high population as compare to other areas. Central west and South-west of the country are densely populated.

It has both central government and local governments for the effective management of administrations activities. Kenya local authorities are classified as City, Municipality, Town or county councils [3]. It has three cities namely Nairobi, Mombasa and Kisumu but Nairobi being the capital city. There are also big towns, small towns, and village set up as well. Figure 2 is a flow chart that shows administration levels in Kenya. There are no fully published data about this system since it is still at early stages since it was implemented in 2010 [4].

Land is counted as valuable economic resource in several ways in Kenya. Example farmers use the land for agricultural functions. Industries also use the land to extract natural resources and to build other manufacturing factories. The main economic activity is predominantly agriculture, which is both a source of food as well as a revenue earner [5].

However, this economic activities release contaminants into the environment through various sources such as metal smelting and refining industries, agricultural activities, scrap metal dealers, plastic and rubber industries, several consumer products and burning of waste containing heavy metals or POPs. Through these activities, the heavy metals are deposited

in soil and they can persist in the environment for many years [6].

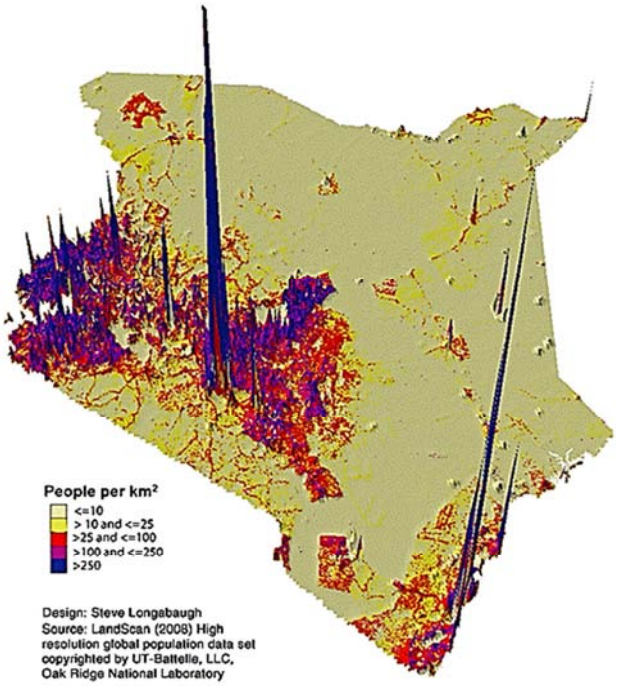

Figure 1. *The population density of 47 counties of Kenya adapted from (steve Longabaugh, 2008).*

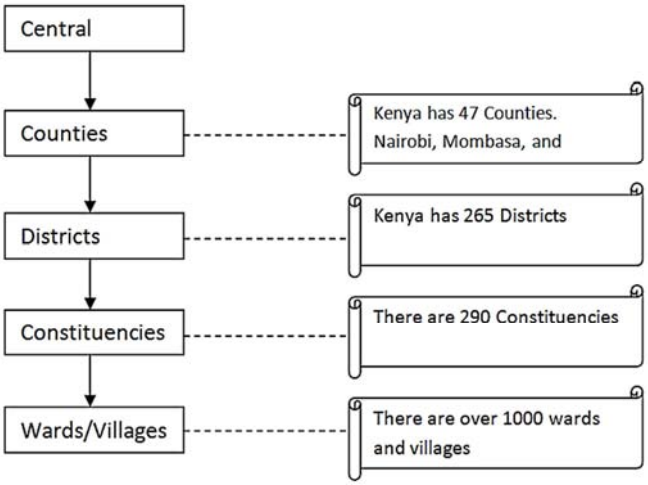

Figure 2. *Kenya's administration level flow chart.*

The impact of industrial development on the environment in Kenya's agricultural sites cannot be underestimated. The consequences brought by industrial pollution affect both human health and environmental. The soil pollution has a negative impact on the safety of food production also [7].

The aim of this study is to review the sources of contaminats into the soil, analyse most popular contaminats in Kenya, reviewed the health implications of these contaminats and finally higlihts the legal framework relating to environment in Kenya.

2. Locations of Industries and Farmland in Kenya

Even though industries in Kenya are small and few, they are rated as most sophisticated in East Africa. Factories and industries have been increasing year after year since mid of the 1990s [8]. Most industries are established in Capital city Nairobi, followed by other cities such as Mombasa, Kisumu, Eldoret and Nakuru. This is the reason why these places are densely populated as in Figure 1.

Potential locations for Industrial Parks include Nairobi due to its proximity to most important markets, Eldoret due to its location in a high-potential agricultural area and access to airport facilities, while Kisumu is due to easier access to regional markets and availability of raw materials such as limestone being mined in Koru, chemicals (e.g. ethanol from sugar factories). Only a few counties such as Kericho, Bomet, Kapsabet, Nandi and Nyeri have factories for farm products such as tea and coffee, whereas Samburu, Narok and Eldoret have wheat industries. Kitale is another county that has maize factories, because this area is a maize intensive area. However, farming is done across the country either small scale or large scale; large scale mostly take place in rift valley province, and central provinces, but a small scale is carried everywhere. Figure 3 and Table 1 below show distributions of economic activities in Kenya.

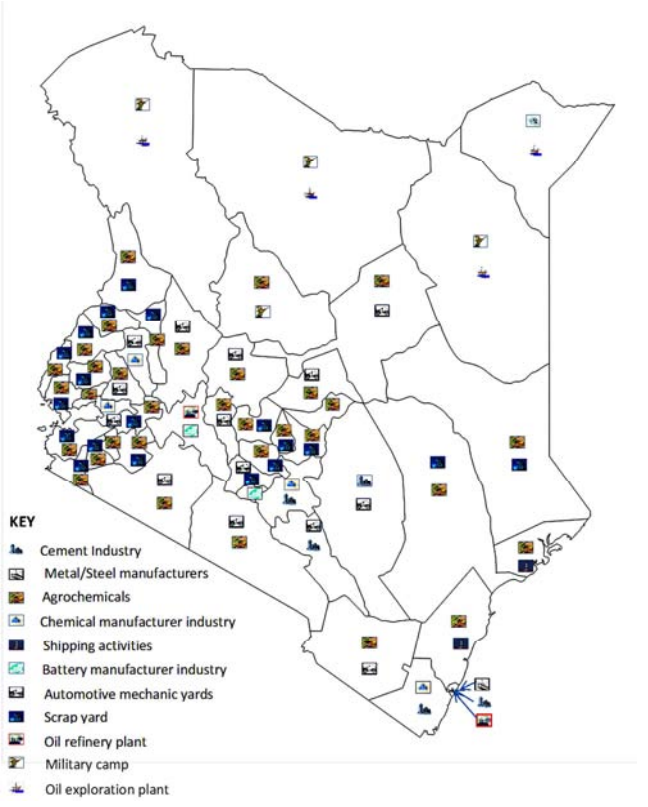

Figure 3. *Kenya's economic activities distributions map. Amended based on Google map 2011.*

Table 1. *Kenyan's economic activities distributions and their possible associated pollutants (amended based on Google map).*

Location	Economic activities	Possible pollutants
Nairobi city	Paint industries, Battery factories, Chemical industries, Plastic factories, Cable and metals industries, Pharmaceutical industries, Vehicles assembly factories, Automotive mechanic yards, Urban farming and Scrap yards etc.	Many inorganic and organic pollutants,
Mombasa city	Oil refineries plants, Cotton mill industry, Agrochemical industries, Paints industry, Iron sheets manufacturers, Rubber factory, Cement factories etc.	Many inorganic and organic pollutants
Kisumu city	Sugar factories, Molasses factory, Agrochemical industry, Pharmaceutical industry, Paints industries etc.	Many inorganic and organic pollutants
Nakuru town area	Oil refinery plants, Batteries industries, Agro-chemical factories, Carbon dioxide plants, Fertilizer factory, Automotive mechanic yards etc.	Many inorganic and organic pollutants
Eldoret town area	Textile industries, Laminate tubes plants, Agro-chemical factories, Maize milling industries, Soap and detergents factory, Scrap yards etc.	Many inorganic and organic pollutants
Kericho, Bomet and Kisii counties	Crop and livestock farming, Tea factories, Milk plant, Scrap yards, and Automotive mechanic yards	Cd, Pb, Cu, Zn, Pesticides, Herbicides, Furan and Dioxins
Kajiado and Narok counties	Crop and livestock farming, Scrap yards, and Automotive mechanic yards	Cd, Pb, Cu, Zn, Pesticides, Herbicides, Furan and Dioxins
Machakos, Makueni and Kitui Counties	Cement factories, Agro- chemical factories, Crop and livestock farming, Meat factory, Scrap yards, and Automotive mechanic yards	All inorganic and organic pollutants
Samburu, Garissa and Isiolo counties	Crop and livestock farming, Scrap yards, and Automotive mechanic yards	Cd, Pb, Cu, Zn, Pesticides, Herbicides, Furan and Dioxins
Turkana, Baringo, West Pokot counties	Crop and livestock farming, Geothermal plants, Oil exploration Scrap yards, and Automotive mechanic yards	Cd, Pb, Cu, Zn, Pesticides, Herbicides, Furan and Dioxins
Wajir, Marsabit, and Mandera counties	Oil exploration, Scrap yards, and	Cd, Pb, Cu, Zn, Pesticides, Herbicides, Furan and Dioxins
Kilifi, Lamu, Kwale and Tana river counties	Crop and livestock farming, Scrap yards, Shipping activities and Automotive mechanic yards	Cd, Pb, Cu, Zn, Pesticides, Herbicides, Furan and Dioxins

3. Causes of soil Pollution in Kenya

Soil contamination is posing major challenges to the environment, organisms, and human beings. Kenya being one of the fast economy growing nations in African is facing many problems to control the rising of land pollution. Poor urban planning and management of resources, lack of monitoring of anthropogenic activities, lack of technical capacity, shortage of trained personnel and lack of enforcement of the relevant environmental law are factors that may be accelerating pollution in soil. One-sixth of total arable land in Kenya has been polluted by contaminants [9].

Currently, vehicles on Kenya's road daily approximated to be over 3,000,000. All of them are attributed to the present of heavy metals especially lead along the roadsides. Traffic induced lead as a result of using leaded gasoline and also wearing down of vehicles tires can also release Lead [10]. Again, each of these vehicles is at least valeted two times a week, either in a constructed car wash along urban pavements or within the compound. Heavy metals such as Cr from paint, Pb from acid accumulators, and Hg from stabilization system are some of the by-products of car valeting will end up in soil and hence destroying the spectrum of food webs [11]. Again, there are a number of oil tankers accidents a long Kenya roads, but only a few which are serious has been recorded. Between 1998 to 2011 statistically recorded six serious oil tanker disasters [12]. Through these oil spills contribute to the present of contaminants in Kenya soil.

Wastes generation in Kenya either domestic or commercial released are increasing fast. 2, 400 tons of garbage are generated daily in Nairobi city alone [13]. Repair and maintenance services are a source of waste oil and oil-contaminated solid wastes that are often disposed of in dumpsites. Less than 10% of waste oil generated is actually collected, which is approximately 33,000 tons per year [13]. Approximately 150 industries are plastic manufacturing, which has an annual growth rate of 6% in Kenya. Plastics contribute 28% of Cd and 32% Pb are found in municipal solid waste [14].

3.1. Different Sectors and the Associated Pollutants in Kenya Soil

The environmental pollutants that are released by industrial, or agricultural activities in Kenya are heavy metals such as Lead, Mercury, Cadmium, Arsenic, Chromium, Zinc, Nickel, Copper and other contaminants [15]. Table 2 contains several contaminants in many parts of the country summarized from different journals. All of them categorized into agricultural sector, industrial sector, hospital sector and natural associate pollutants. The following are the major sources of pollutants to soil:

a) Agricultural sector: With the heavily used of chemicals such as pesticides various studies carried out in Kenya have confirmed the presence of Persistent Organic Pollutants (POPs) in the environment. These pollutants are one of the causes for the rise of cancer and other diseases cases in Kenya [14]. Tea and coffee estates deposit pesticides, herbicides, and fertilizers in soil because of regular usage.400 tonnes of pesticides and fertilisers are released every year to the environment from farming activities [13].

b) Industrial sector: Many industries such as smelting industries and battery manufacturing factories, release uncontrolled wastes to the environment [16]. According to the ministry of environment and mineral resources,

agro-chemical from cane washing deposits pesticides, herbicides and fertilizers into the soil [13]. There also disposal of small firearms in the military camps, and cattle rustling in some places such as Samburu and Pokot [17].

c) Hospital sector: Hospital packaging materials and containers, used syringes and sharps needles, biological waste and pharmaceuticals are wastes released from hospitals. Other contaminants such as dioxin, furan and some toxic metals (Hg, Pb, Cd, Cr and Mn) are released from incineration activities [14]. Kenya's hospitals generate approximately 10,000tons of medical wastes per year [13].

d) Natural source: Natural volcanic eruptions especially Rift valley province [18], contribute to soil pollution in Kenya. Some soils naturally contain some of the heavy metals that are considered as a health risk. The metals that are released into the environment due to volcanic eruptions are Mn, Cu, Zn, Fe, and Ti.

Table 2. *Industrial sectors and the associated pollutants in Kenya soil.*

Industrial sectors	Specific polluting activities	Associated pollutants	Location discovered	References
Agricultural	Agricultural activities (use of inorganic fertilizers and pesticides)	Cu, Zn, Pb, Cd, Mn	Kenya Coast Region	[19], [20]
		Pb, Cu, Fe, Zn	Kapsabet County	[21]
		Cd, Zn	L. Nakuru National Park	[22]
		Pb, Cr, Cd, Zn, Mn	Samburu County	[17]
	Agricultural activities(use of organic fertilizers)	Antibiotics(Sulfamethoxazole, sulfamethazine, and enrofloxacin	Mai Mahiu, Narok, Mount Suswa Conservancy	[23]
	Flower Farm and Influx of municipal effluents	Cd, Zn	L. Nakuru National Park	[22]
		Pb, Cd, Cu, Zn, Fe	Eldoret Town	[24]
	Agricultural activities around dumpsite and sewage area	Cu, Pb, Zn	Nairobi Markets	[7]
Industrial	Cement Factory(raw waste discharge)	Pb, Zn, Cu, Mn, Ti	Kitui South	[25]
		Pb, Cd, Cu, Cr, Ni	Machakos County	[16]
		Pb, Cu, Ni, Zn	Kisumu County (L. Victoria)	[26]
	Industrial waste from Oil refinery	Cu, Zn, Pb, Cd, Mn	Kenya Coast Region	[19], [20]
	Anthropogenic activities (Shipping activities, textile factory)	Cd, Cu, Cr, Pb, Zn, Fe	Kisumu and Malindi	[27]
		Cu, Zn, Pb, Cd, Mn	Kenya Coast Region	[19], [20]
	Steel rolling Factory	Cu, Zn, Pb, Cd, Mn	Kenya Coast Region	[19], [20]
	Battery Factories	Pb, Cu, Ni, Zn	Kisumu County (L. Victoria)	[26]
	Agricultural Chemical industry	Pb, Cu, Fe, Zn	Kapsabet County	[21]
		Cd, Zn	L. Nakuru National Park	[22]
		Pb, Cd, Cu, Zn, Cr	Eldoret Municipality	[28]
	Paint Factories	Pb, Cu, Ni, Zn	Kisumu County (L. Victoria)	[26]
	Transport sector (Vehicle emission)	Pb	Nakuru County	[10]
		Pb, Cd, Cu, Zn	Kisii county	
	Kilembe copper smelter	Pb, Cu, Ni, Zn	Kisumu County (L. Victoria)	[26]
	Tea factory and Urban effluent	Pb, Cu, Fe, Zn	Kapsabet County	[21]
		Cd, Zn	L. Nakuru National Park	[22]
	Dumpsites	Cd, Cu, Cr, Pb, Zn	Bungoma	[29]
		Cd, Pb, Hg	Dandora(Nairobi)	[30]
		Cd, Cu, Cr, Pb, Zn, Ni, Hg, Mn	Kadhodeki (Nairobi)	[31]
	Military weapon sector	Pb, Cu, Ni, Zn	Kisumu County (L. Victoria)	[26]
		Pb, Cr, Cd, Zn, Mn	Samburu County	[17]
Hospital	Hospital Waste Incineration	Hg, Pb, Cd, As, Cr, Mn, Dioxins and Furan	Nairobi County	[14]
Natural source	Volcanic eruption	Zn, Pb, Fe	Nakuru Municipality	[18]

3.2. Most Popular Contaminants in Kenya

Table 3 was summarized from Table 2 is an approximate number of times the pollutants has been identified in the locations where researchers did their sampling. Pb has occurred most than any other pollutants, could be because of a number of sources and products used daily by several people that contain traces of Pb metal. While Zinc, Copper and Cadmium also are prominent are of concern likewise the rest of the pollutants. Figure 4 is the graphical diagram of the most frequently occurring pollutants in Kenya's soil, and it is the analysis of the available journals. This study chose the five most popular contaminants in Kenya's soil are Pb, Zn, Cu, Cd and Mn, with a frequency of 27, 26, 21, 20, and 9 respectively. However, if more samples can be done in future of all the pollutants it will give a different graph.

Table 3. *The occurring frequency of different pollutants found in Kenya's soil by various case studies in the literature.*

Pollutant	Frequency
Pb	27
Zn	26
Cu	21
Cd	20
Mn	9
Ni	7
Cr	7
Fe	7
Hg	4
As	2
Antibiotics	2
Dioxin	1
Furan	1

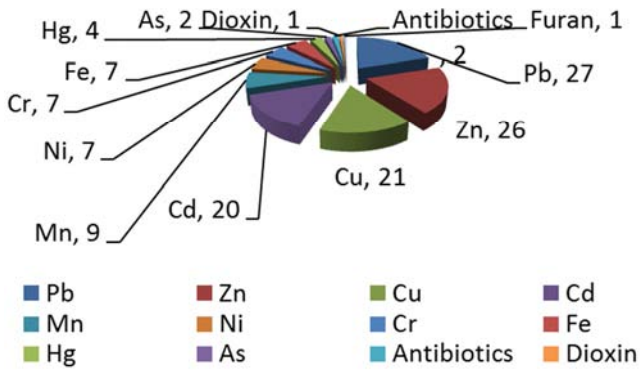

Figure 4. *The occurring frequency of different pollutants found in Kenya's soil by various case studies in the literature.*

3.2.1. Concentrations Analysis of Most Popular Heavy Metals in Kenya

Table 4 and Figure 5 are an overview of the concentrations of heavy metals presented by a different journalist from 11 different locations. The summary enabled to determine the highest concentration of heavy metal comparing with China standard of soil environmental quality standard for agricultural land.

The highest concentration is Zn in Bungoma town is mostly influence by municipal waste which is discharged uncontrollably [29], and Eldoret municipal, Zn in soils could be as a results of discharge from industries in the locality, livestock abattoirs and sewerage treatment plants [28], while in Kitui county is the waste from cement factory. The highest concentration of Mn in Kadhodeki dumpsite is due to municipal waste, while in Dandora dumpsite the biggest dumpsite in Nairobi City, Pb is more concentrated because of the highest waste from number of industries mostly attributed to wastes with Pb content [30].

Nakuru town reported to have high concentrations of Pb [10], most likely because of volcanic eruptions with industrial waste, hospital waste, and vehicular emissions being accelerating the frequency [18]. Again Lake Nakuru National Park recorded the Zn being concentrated in the area is mainly because of industrial wastes from battery industry [22].

Lake Victoria region has the highest concentration of Pb is being attributed to anthropogenic activities such as gold mining and spread of industrial emissions in the area [32]. Whereas concentration of Zn is higher in Lake Victoria basin and the reason could be because of effluents waste from chemical industries, hospital waste and smelters plants located here [26].

Cd recorded the highest concentration of 570 mg/kg and it happen many times to be above the land use Chinese standards. Pb and Zn came in second with their concentration going beyond the standard four times, 619mg/kg and 403.3mg/kg being their highest recorded values respectively. The highest concentration of Cu is 2,089.61mg/kg, while Mn is 14,419.0mg/kg has the least frequencies that have gone above the standards set. The locations of all these concentrations are shown in Figure 6.

Table 4. *Concentrations of most popular heavy metals in Kenya soil from various research papers (mg/kg).*

Location	Heavy metal concentration				
	Pb	Zn	Cu	Cd	Mn
China standard of Soil environmental quality standard for agricultural land in mg/kg	*80*	*200*	*50*	*0.3*	*1200*
Kitui South [L1]	72	170	86	0	0
Lake Victoria Region [L2]	619	0	0	570	0
Kadhodeki Dumpsite [L3]	60.22	289.27	2089.61	0	14419.0
Nakuru Town [L4]	120.8	0	0	0	0
Lake Victoria Basin [L5]	171.5	387.5	51.13	0	0
Lake Nakuru National Park [L6]	0	178	0	16	0
Eldoret Municipality [L7]	0.6810	2.370	0.3492	0.0385	0
Dandora Dumpsite [L8]	560	0	0	52.9	0
Bungoma Town [L9]	10.5	15.38	0	9.52	0
Juja Dumpsite [L10]	3.77	368	0	0.04	0
Samburu County [L11]	67.5	403.3	0	0.76	26.83
Range of concentrations	0-619	0–403.3	0-2089.61	0-570	0-14419.0

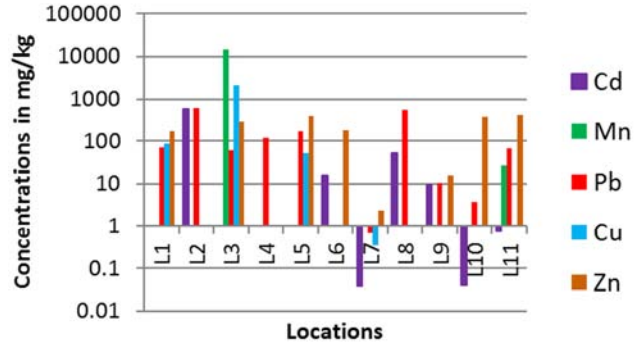

Figure 5. *The highest concentrations of most popular heavy metals detected by various case studies for 11 different sites (logarithm scale).*

Figure 6 representing the distribution of concentrations of contaminants in 11 locations in Kenya. Nairobi(Mn 14419.00mg/kg, Cu 2089.60mg/kg, Pb 560.00mg/kg, Cd 52.90mg/kg and Zn 289.27mg/kg) and Kisumu(Pb 619.00mg/kg, Zn 387.50mg/kg, Pb 171.50mg/kg, and Cu 51.13mg/kg) cities have highest number of contaminants identified that are above the required standard. Therefore, putting risk to a number of people living in these cities and counties. The approximate number of people who are at risk are for example population density of Nairobi city (3,375,000), Kisumu city (1,200,000), Nakuru (1,603,325), Uasin Gishu (894,179), Bungoma (1,630,934), Kitui (1,012,709), and Samburu (223,947) [2].

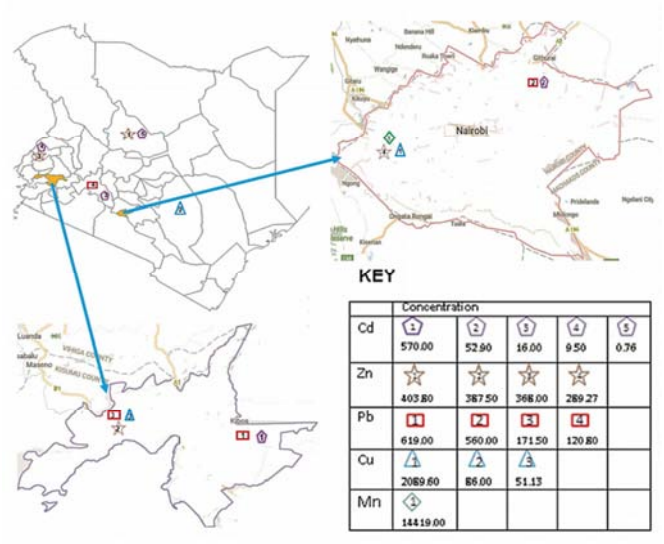

Figure 6. *Highest concentration of heavy metal in 11 locations summarized from literature papers. Amended based on (d-maps. com, 2016). All values of concentrations are in mg/kg.*

3.2.2. Potential Health Risk Level Projection for Kenya

Human health risk map in Figure 7 below is a projection of the possible concentration of contaminants in different places across Kenya, which needs further research. Figure 3 and Table 2 are a summary of a number of economic activities in Kenya are only those which has been identified (locations are in Google map). The figure is divided into five main parts, depending on the economic activities found in that area.

High-risk area painted with the black color represents main cities (Nairobi, Mombasa and Kisumu), whereby there are many economic activities taking place. Many industries such battery manufactures, paints industries and cement industries are concentrated in these areas. There are other activities for example urban agricultural activities and solid waste management. Most likely organics and inorganics contaminants can be determined in this area. Medium-high risk area represented by dark red color, and there are an average number of industries and farming activities located in these areas. These industries releases contaminants (all inorganics and organics).

The pink color is medium risk areas because of medium concentration of Cd, Cu, Pb, Zn, Furan, Dioxin, pesticides and herbicides that are discarded to soil because of intensive farming activities. A low-medium concentration of Cd, Cu, Pb, Zn, Furan, Dioxin, pesticides and herbicides is due to few farming activities. These areas are represented by dark orange color, while light green color is areas that have scattered farming activities. Mandera, Taita taveta and West Pokot have very few activities such as cattle farming hence counted as low-risk area due to possible low concentration of Cd, Cu, Pb, Zn, Furan, Dioxin, pesticides and herbicides that are deposit to soil.

There are those activities that are common across the country such as scrap yards and automotive mechanic workshops due to increasing number of vehicles on the roads and scrap waste generated every day.

Every pollutant is being associated with the type of economic activity found in that place. For example, paints and batteries factories area associated with Pb accumulation, while agricultural activities are being associated with Pb, Cd, Cu and Furan. Therefore urban areas most likely to have concentration of all inorganics and organics pollutants [33], whereas rural areas where crop and livestock activities are taking place probably have high concentration of Cd, Cu and Furan in the soil. Other places such as Northern part of Kenya will be in the near future most likely to record an increase of Pb and Cd due to oil exploration. Along Kenya's roads has been reported to have higher concentration of Pb, this because of vehicle emission and automotive mechanic yards [10], [11]. The presence of all these pollutants in the soil imposed health risk to human being as discussed in the following case studies. Therefore, there is need for further studies in many areas in Kenya especially those places projected as high risk and medium high-risk areas.

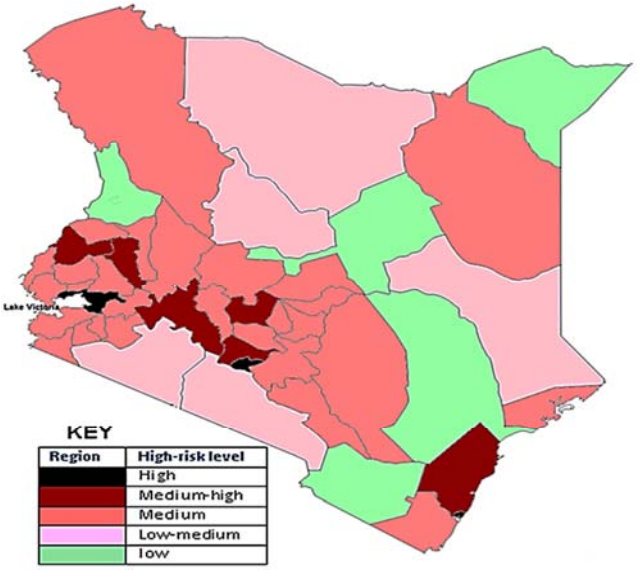

Figure 7. *Projection of potential human health risk level for Kenya based on current economic activities.*

4. Case Studies of Health Implications of Contaminants in Kenya

In Kenya, some health effects have been diagnosed which is believed to be as a result of heavy metals. People who are living in urban areas, near dumpsites, or within the vicinity of mining factories are more vulnerable to the impacts posed by the heavy metals present in the soil [34]. Very few investigations has been done on the effects caused by contaminants in the rural setting in the literature. However, the heavy use of fertilizers and pesticides for tea, coffee, maize, wheat, and flowers accumulate heavy metals and POPs in the soil until a certain level that could be a threat to human health and the environment.

The main sources of lead metal in the soil include industrial processes such as lead smelting, coal combustion, gasoline emission, lead-based paint, lead-containing pipes, improper

disposal of lead oxide batteries, and use of glazed ceramics [35]. Batteries are widely used in Kenya's homes, micro business sectors and also public premises to back up batteries of computer systems, lights, and others appliances such as radios and television sets [36].

Studies have been carried out on the effects of Lead on the people working in plants associated with this toxic metal and people living around areas that are considered to have high concentration of Lead [37]. Below are case studies that have been carried about implications of Lead poisoning and other contaminants.

4.1. Case Study 1: Blood Lead Levels in Nairobi City

The research was done between March and October 2005 [38]. Figure 8 shows the location of the study area, which is around Dandora biggest dumpsite in Nairobi City. It was determined the levels of lead in Nairobi Central Business District (NCBD) were above the WHO standard.

Figure 8. *Case 1 study area. Around Dandora dumpsite area adapted from google map 2016.*

Health effects of lead metal

Table 5 below contain a summary of blood lead levels from blood samples taken from 308 residents around Dandora dumpsites range from 0.4µg/dl to 65.0µg/dl, with a mean concentration of 8.0µg/dl. Further study found that 328 children and adolescents between 2 and 18 years were suffering from diseases such as Dermatological (skin disorders), Respiratory, Gastroenteritis, Dental disorders, Skeletal /muscular systems, Central nervous system, Eye infections, and Blood (anemia), which most likely to be associated with contaminants poisoning [15].

Table 5. *Statistical analysis of children and adolescents (aged 2-18years) affected by the heavy metals. Adapted and amended based on [38].*

System affected	No. of children and adolescents affected	Those who have disorders in (%)
Dermatological (skin disorders)	48	14.5
Respiratory	154	46.9
Abdominal and intestinal problems	59	17.9
Dental disorders	31	9.5
Oto (affecting the hearing system)	15	4.6
Skeletal /muscular systems	8	2.4
Central nervous system	7	2.13
Eye infections	32	9.8
Blood (anemia)	1	0.3
Others*	21	6.4
Normal	26	7.9

Others*: Malaria, chicken pox, septic wounds, congenital abnormalities, cardiovascular diseases and lung cancer

4.2. Case Study 2: Health Problems in Eldoret

The study done shows that Zn, Pb, Cu, and Cd were prevalent metal associated to diseases recorded in that area [39],[40]. Zn was determined to be most prevalent for the observed diseases and Cd being the least. Cancer, stroke, hypertension and cardiovascular diseases are the diseases associated with stated heavy metal by this report.

Figure 9. *Eldoret Municipal location. Amended from Google map 2016 and http://www.geocurrents.info/gc-maps/geocurrents-maps-by-country/geocurrents -maps-of-kenya.*

Zn accounted for highest (49.83%) of the variance followed by Pb (27.01%) in cancer cases Cd was the lowest with less than 1%. For hypertension conditions, Zn accounted for 38.47% followed by Pb with 29.80%; Cd was the lowest with 3.53% [40]. Equally, Zn accounted for 45.54% for stroke followed by lead with 34.73% for stroke and Cd being the lowest (1.93%). In cardiovascular diseases, Zn accounted for 46.02% followed by Pb with 28.12% and Cd being the lowest (1.41%). Table 7 is the sampling zones whereby it shows that diseases incidences varied within each sample site. Cardio-vascular related diseases and hypertension recorded the highest frequencies of 12 and 9 in Jua kali and Kahoya zones respectively.

Table 7. *Diseases associated with toxic metals in Eldoret. Adapted and amended from [40].*

Sampling zones	Metal concentration (mg/kg)	Diseases	The number of people
Juakali (n=20)	Zn -1.6	Cancer	3
	Pb -0.602	Hypertension	4
	Cu -0.2878	Stroke	1
	Cd -0.0298	Cardio-vascular diseases	12
EATEC (n=15)	Zn -1.739	Cancer	5
	Pb -0.606	Hypertension	6
	Cu -0.254	Stroke	3
	Cd -0.0272	Cardio-vascular diseases	1
Yamumbi (n=8)	Zn -1.5165	Cancer	4
	Pb -0.681	Hypertension	2
	Cu -0.3492	Stroke	1
	Cd -0.0385	Cardio-vascular diseases	1
Kahoya (n=19)	Zn -2.37	Cancer	3
	Pb -0.56	Hypertension	9
	Cu -0.287	Stroke	1
	Cd -0.0196	Cardio-vascular diseases	6
Hawaii (n=6)	Zn -1.6364	Cancer	1
	Pb -0.662	Hypertension	1
	Cu -0.2758	Stroke	2
	Cd -0.0298	Cardio-vascular diseases	2
Total			68

5. Evironmental Legal Framework in Kenya

For quite a length of time, Kenya did not have a comprehensive legislative framework for environmental regulation. Environmental Management and Coordination Act (EMCA) Act 1999 contains the summary of over 77statutes and regulations that govern the environment combined with a common law. EMCA seeks to coordinate the activities of the various agencies tasked to regulate the various sectors [41].

Kenya has some standards initially implemented to prevent the release of pollutants to environment. Nevertheless, there is lack of enforcement mainly due incentives, which are not enough [42]. Kenya does not have soil quality standard as in neighbouring countries such as Uganda and Tanzania [43]. There is insufficient coordination between the major actors in the agricultural sector (e.g. infrastructure development, water, land settlements), and of activities within the Ministry of Agriculture and Rural Development. This situation does not help to address the numerous constraints to effective soil fertility management, and agricultural production in general.

6. Conclusion

The main types and distribution of industries in Kenya were identified based on literature publications such as journals, reports, governments websites such as the ministry of environment and natural resources of Kenya, international website for instance WHO and also other recognized academics institutions. It is a clear indications of future that there will be an increase number of industries across the country especially when considered kenya as fastest growing in terms of economy in East Africa region. This study has clarified the possible contaminants from these economic activities which have been summarised into agricultural, industrial, and hospital sectors, also natural sources which are not prominent in Kenya.

The summary reviewed shows the Pb recorded the highest value of 619mg/kg in Lake Victoria region which is eight times higher than China standard limit concentration of this heavy metal in the soil. Higher concentration level recorded for Zn is 403.3mg/kg in Samburu county which is two times higher than the standard of 200mg/kg of China. Cu is 2089.61mg/kg which is 42 times higher than 50mg/kg set for China standard, while Cd which is considered to be most toxic metal recorded a value of 570mg/kg in Lake Vitoria Region is 1900 times higher than the set standard of 0.3mg/kg for China. Mn which appeared only once from the review recoreded concentration level of 14419mg/kg in Kadhodeki dumpsite in Nairobi city. The highest concentration recorded in these areas is threat to the health of the population leaving in these areas.

The case studies reviewed in this paper confirm the implication of soil contamination so far that has been determined. These studies were carried in Nairobi city and Eldoret municipality, were only done in small section of area. Furthermore, the two case studies reviewed in this dissertation has linked the soil contamination with some diagnosed diseases.

Further Research

The review of this dissertation has highlighted some of the areas on which further research would be of beneficial. Numerous areas where information is lacking were underlined in the study include the following;-

- More investigation on possible pollutants that are toxic humans, animals and plants health. The main factors to consider when analysing the soil sampling are having knowledge on soil characteristics, PH, geology, habitat, topography, profile, and anthropogenic influences from industries. These factors especially soil characteristics and geology of Kenya has not been clearly established to enable the researchers to do an indepth study on the present of contaminants and its mechanism in the soil.
- More soil samples should be analysed to determined the concentrations of the contaminants at different places both in rural where agricultural activities are done and also in urban centres where there are a number of industries established.
- Many samples to determined the link between the common diseases and concentrations of heavy metals in many places in Kenya.

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