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RESEARCH ARTICLE

IMPACT OF GOLD MINING ON VEGETATION AT KOMABANGOU AREA

[1,*]Ousseini ZAKARIA IBRAHIM, [1]Abdourahamane TANKARI DAN-BADJO, [2]Ibrahim ELHADJ DAOU, [1]Fanna ADBOU GADO, [1]Karimou Jean Marie AMBOUTA and [1]Yadji GUERO

[1]Department of Soils Science, Faculty of Agronomy, University Abdou Moumouni de Niamey, Niger
[2]Department of Mining Engineering and Environment, School of Mines, Industry and Geology of Niamey, Niger

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ABSTRACT

This study was conducted at Komabangou gold zone. The objective of the study is not only to determine metal trace element concentrations in the leaves of two (2) plant species at Komabangou gold site, but also to determine the extent of deforestation associated with gold washing. Investigations are carried out by methods of evaluation of deforestation and determination of the concentrations of MTE in the leaves of two plant species by inductively coupled plasma optical emission spectroscopy (ICP-OES). Results showed that to support 797 functional wells at Komabangou gold site, 261416 trees were destroyed almost 328 tree trunks per well, suggesting a negative impact of gold panning at Komabangou vegetation. The descriptive analysis shows that both species accumulate high levels of MTE. Also, the herbaceous tend to accumulate more MTE than ligneous ones. The concentrations of MTE detected in plant leaves can reach up to 656.68 mg / kg. They exceed WHO standards of 3, 5, 7, 9, 10, 15, 67 and 79 respectively for copper, nickel, zinc, cadmium, chromium, cobalt, lead and arsenic for herbaceous plants and 1, 2, 3, 4, 5, 23 and 30 times higher than WHO standards for zinc, arsenic, chromium, nickel, lead and cobalt for ligneous plants. The presence of metals in leaves of these plants at levels above regulatory standards therefore poses a health risk to grazing animals at Komabangou gold zone. This gold recovery site should be secure to limit risk of metal transfer into the food chain.

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INTRODUCTION

Human activities such as industrial production, agricultural practice, transportation, and mining release large amounts of Metallic Trace Elements (MTE) into the ecosystem (Gond *et al.*, 2014; Rasheed and Abdulgafar. , 2014). MTE are bio-accumulated and bio-transferred by natural and anthropogenic sources. Plant contamination by MTE is one of the major problems facing world and requires special attention (Popescu *et al.*, 2009, Prospero *et al.*, 2002). The accumulation of these MTE in crop plants is of great concern because of the likelihood of food contamination (Kassaoui *et al.*, 2009). Although MTE such as Cd, Pb and Ni are not essential for plant growth, they are readily absorbed and accumulated by plants in toxic forms (Mpundu *et al.*, 2013). The consumption of plants grown on soils contaminated with MTE poses a risk to human health (Bamba *et al.*, 2013).

***Corresponding author: Ousseini ZAKARIA IBRAHIM,**
Department of Soils Science, Faculty of Agronomy, University Abdou Moumouni de Niamey, Niger.

Indeed, MTE act on quality of food and therefore on health (Tankari Dan-Badjo *et al.*, 2007). As well, these MTE can affect soil ecology, agricultural production, and biodiversity. These effects are closely related to the bioavailability of MTE, themselves controlled by speciation of metal ions in the soil (Ene *et al.*, 2010).The discharge of wastewater into the polluted environment. Plants that grow on polluted soils are contaminated with these metals-laden waters may in turn contaminate and pose a risk along the food chain. In addition, increased pollutant deposition, such as MTE on plants, has been raised (Tankari Dan-Badjo *et al.*, 2007). Many authors (Lykke 2000, Sinsin 2002, Ouedraogo *et al.*, 2006) have shown that human activities have a negative impact on the structure and dynamics of forest ecosystems. Some preliminary investigations to the impact of gold panning at Komabangou reveal a significant contamination of water and soils, but also highlight a significant variability of concentrations of MTE depending on metal analyzed (Amadou, 2011, Ali, 2013, Tankari Dan-Badjo *et al.*, 2015).

It is in this context that this study was initiated. It aims to determine the impact of gold mining at Komabangou gold zone.

MATERIALS AND METHODS

Site Description: The study area located in the northwest of Niamey city at about 150 km. It is a large area with a high density of gold-bearing indices and geochemical anomalies. From Niamey, it is accessible via the paved road of Tillabéry or that of Namaro, national road N° 103 towards Dargol and Boura, then by lateritic track to sandy at 26km to the site. Located between latitude 14 ° 01'41"and 14 ° 07'56 " North and longitude 01 ° 02'12"and 01 ° 10'00 " East, it covers an area of 157 km^2 with a population estimated at 36937 inhabitants distributed in 18 villages (Amadou, 2011). Figure 1 shows the geographical location of the Komabangou gold zone. The site is very rich in gold, which is exploited in a traditional way. The sites of exploitation are very disordered, strewn by wells in form of galleries. Figure 2 shows Heaps of rock or sterile sands discharged during digging of gold-bearing vein.

Collection of plant samples: Two plant species were collected including one herbaceous, *Datura inoxia* and one ligneous, *Calotropis procera*. The choice of these species is justified by their presence on almost all gold panning sites at Komabangou area. They were collected using pruning shears at four (4) cyanidation sites commonly called "Grillages".

Mineralization: The samples were dried and ground in a fine powdered mortar. 0.5 g of each sample was taken and put into 50 ml flasks. 6 ml of 65% concentrated HNO_3 and 1 ml of hydrogen peroxide were added to each sample. The mixtures were left for 24 hours under cold conditions and then placed in a Digiprep (Sorbonne) at about 95 °C for 120 minutes.Solutions were cooled to 20 °C. 13 ml of deionized water was added to the solution for filtration and adjusted to 25 ml before switching to ICP-OES (Swaileh *et al*., 2009, Swaileh *et al*., 2004).

Dosage of the MTEs: MTEs such as Zn, Co, Cu, Cr and Pb were detected using NF ISO 11885 AA240 FS by high frequency inductively coupled plasma optical emission spectroscopy (ICP-OES) based on comparison with standards external. The standards were freshly prepared from standard metal solutions and were used for the initial calibration of each substance. The concentrations of MTEs are expressed in mg/kg. Statistical calculations such as averages, minimums, maximums, medians and standard deviation have been performed with the Excel software.

Estimate the extent of deforestation at Komabangou goldsite: To estimate the extent of deforestation at Komabangou gold site, the direct count of functional wells per site was first performed. Then, total number of trees felled for operation of a well was calculated using the following formula:

$NT = [Ng * L * Na] + Ntc$

NT = total number of trees felled per well

Ng = average number of galleries per well

L = average length of a gallery in m

Na = average number of trees felled for the support of one meter of gallery

Ntc = average number of trees felled for winch support and shed construction per well. Finally, total number of trees felled on the entire Komabangou gold site is estimated by summing the number of trees felled for each site.

RESULTS AND DISCUSSION

Estimated extent of deforestation at Komabangou gold site: Estimation of felled trees related to gold panning activities in Komabangou is shown inTable I who revealed that 797 functional wells were identified at Komabangou gold site. Knowing that an average of 328 tree trunks are required for a functional well, an average of 261 416 trees must be cut down for strong support of all functional wells. Table I also shows that Transa site shows the highest number of trees felled (91,840) or 35.13% followed by Maigimaâ site with 43,296 trees felled or 16.56%. The smallest number of felled trees is observed at Foulankoira site (328 trees felled) or 0.12% followed by Kékirey (656 trees felled) or 0.25%.These differences could be explained by the density of gold miners which is higher at Transa than at Foulankoira because of the instantaneous discovery of new gold veins which creates the rush of miners to this site. This estimate of the extent of deforestation at Komabangou area differs from that obtained according to a study in Burkina Faso conducted by Kelvine (2012) and Hien (2012), the first claiming that about 500 trees are needed for strong support a well while the second has shown that it takes about 600 woods for the support of a well. These high numbers compared to the results of the present study (328 trees) can be explained by the fact that in Burkina Faso, the support starts from the surface because of the low lift of the soil, which requires an excessive use of wood. In addition,Ibrahima (2009) vegetation dynamics analysis showed that the vegetation, in particular the heavily degraded shrub steppe, underwent a very significant change between 1988 and 2005, from 40,903 ha to 32,713 ha. . This is due to the heavy use of woody plant resources due to intense mining activities by an ever-increasing population.

ETM contents in plants growing on the Komabangou site: The results of MTE concentrations in leaves of Datura and Calotropis are reported in Table II. Analysis ofthis Table 2 shows a variability of average MTE concentrations according to plant material collected. Indeed, it is found that the contents vary from 0.05 to 656.68 mg/kg. The lowest concentrations were detected for Cd with 0.05 mg/kg and 0.25 mg/kg respectively in woody and herbaceous samples. The highest averages were detected in Zn with 153.88 mg/kg and 656.68 mg/kg respectively in woody and herbaceous samples. These values are very close to those obtained by Mpundu *et al*., 2013 in the plants of amaranth and pear perry harvested on soils of the kitchen gardens of the mining town of Lubumbashi in Congo where the levels detected ranged between 0.1 mg/kg and 653.3 mg/kg with low concentrations for Co (0.1 mg/kg) followed by Cd (0.6 mg/kg) and the highest concentrations for Zn (653.3 mg/kg). Also, analysis of this table shows variable average contents depending on plant species and the MTEs considered. In fact, for herbaceous plant species, the highest average content is observed in Zn with a concentration of 338.23 mg/kg, a maximum of 656.68 mg/kg, while the lowest is observed in Cd with a value of 0.44 mg/kg and a minimum of 0.25 mg/kg. For ligneous plant species, the highest mean concentration was detected in Sr with a value of 182.50 mg/kg and a maximum of up to 213.57 mg/kg while the lowest was detected for Cd with a value of 0.06 mg/kg and a minimum falling to 0.05 mg kg.These results therefore show that average concentrations are higher for herbaceous plant species.

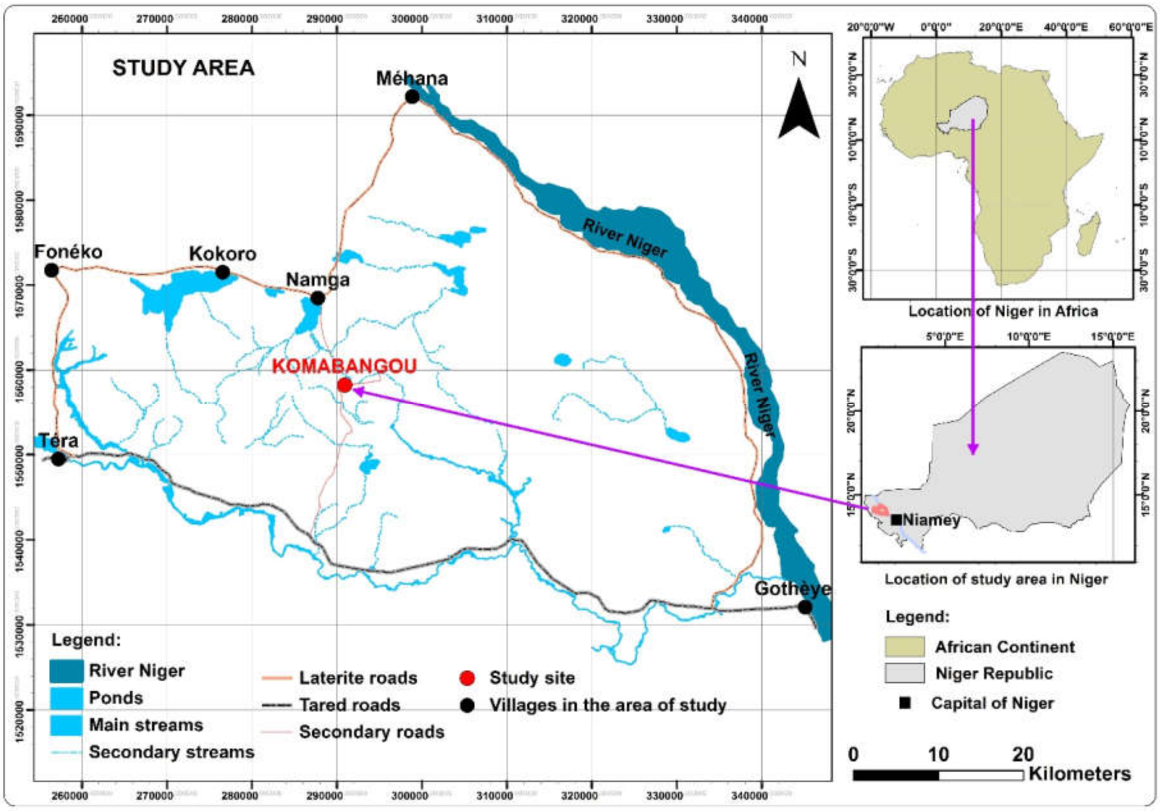

Figure.1. Location of the Komabangou gold site

Table 1. Estimation of felled trees related to gold panning activities in Komabangou

Sites	Geographical coordinates Latitude North	Longitude East	Altitude in meters	Number of functional wells per site	Number of trees felled per well	Number of trees felled per site
Gawado	14°05'01,7"	001°03'25,6"	275	60	328	19 680
Bédérène	14°05'02,6"	001°03'33,0"	281	25	328	8 200
Transa	14°05'03,7"	001°03'50,7"	286	280	328	91 840
Kouaché	14°05'07,3"	001°04'05,7"	289	50	328	16 400
Abdallah	14°05'13,7"	001°03'27,4"	283	50	328	16 400
Dandabino	14°05'26,1"	001°03'22,6"	276	37	328	12 136
Réseau	14°05'33,8"	001°03'12,5"	271	17	328	5 576
Boussoun-Boussoun	-	-	-	23	328	7 544
Maijimaâ	14°05'32,1"	001°03'28,9"	279	132	328	43 296
Station	14°05'25,4"	001°03'35,2"	281	18	328	5 904
Nakia	14°05'56,7"	001°03'25,5"	272	15	328	4 920
Bambara	14°05'24,8"	001°02'39,0"	270	25	328	8 200
Kouwa-bouzou	14°06'42,6"	001°04'30,6"	274	27	328	8 856
Karanguiya	14°05'05,1"	001°05'54,1"	283	10	328	3 280
Bibiéko	14°05'33,2"	001°06'06,2"	270	25	328	8 200
Foulankoira	14°04'14,1"	001°05'9,3"	275	1	328	328
Kékirey	13°58'59,1"	001°02'52,0"	288	2	328	656
Total	-	-	-	797	328	261 416

Table 3. Comparison of the mean concentrations of MTEs in Datura and Calotropis leaves at Komabangou gold site with guide values (mg/kg)

MTEs	Herb samples (n = 4)		Woody samples (n = 4)	
	Mean	Standard value	Mean	Standard value
As	134.67	nd	49.30	nd
Cd	0.44	2**	0.06	2**
Co	3.08	1***	6.06	1***
Cr	14.29	nd	6.45	nd
Cu	27.97	10***	12.52	10***
Mo	2.36	nd	2.49	nd
Ni	8,04	8*	7,23	8*
Pb	67,18	3**	23,23	3**
Sr	155,39	nd	182,50	nd
Zn	338,23	17**	112,05	17**

* WHO standard (GODIN, 1983; Kassaoui *et al.,* 2009

**CMR standard established in France ((Mench& Baize, 2004)

***Finnish Standard (Kabata-Pendias)

nd= not determined = value> at the threshold

(a)

(b)

Figure 2. A and B.Deposit of slag heaps at Komabangou gold site

This indicates that these herbaceous plant species are the most contaminated and/or most accumulative MTEs. This is explained by their physiological capacity to absorb MTEs. Also, these herbaceous plant species have a root system that is not deep, exposing them more to MTEs. These results of this study are lower than those obtained by Mpundu *et al*., (2013) in amaranth and beetroot plants harvested from the soils of Lubumbashi vegetable gardens in Congo, where highest average concentration was detected for Zn with an average value of 196.9 mg/kg and a maximum of 653.3 mg/kg whereas while the low level was observed in Co with a value of 2.7 mg/kg and a minimum of 0.1 mg/kg. This difference is explained by the fact that the plants collected and the land studied are not the same.

Comparison of the MTEsconcentrations in studied plants with guide values: Table III presents a comparison of MTEs concentrations in Datura and Calotropis leaves with regulatory limit values. This Table shows that all average MTEs concentrations in herbaceous and woody plant species are above regulatory values.In fact, international standards values for food are exceeded for Co, Cu, Ni, Pb and Zn. For Cu, average concentrations measured in herbaceous and woody plant species are respectively 2.8 and 1.25 times than standards set by the Finnish standard of 10 mg/kg.The average Pb concentrations in herbaceous and woody plant species are 22.4 and 7.74 times higher than the recommended average concentration (CMR) established in France for leafy vegetables. For Zn, mean concentrations of herbaceous and woody plant species are 19.9 and 6.6 times higher than WHO standards according to Godin (1982) and Kassaoui *et al* (2009) on foodstuffs.The average Ni concentrations measured in herbaceous and woody plant species are slightly higher (1.005 times) than the WHO standards. All these results are different from those obtained by Mpundu *et al* (2013). In fact, they had found concentrations of Co, Cu, Cd, Pb and Zn for amaranth, which exceeded WHO standard values of 2.7; 2.8; 2; 3.5 and 8.5 times. At the level of periwinkle plant species, Mpundu *et al*. (2013) found that concentrations of Co, Cu, Cd, Pb and Zn respectively exceed 5; 4; 2; 4 and 12 times. The high concentrations of MTEs measured at herbaceous and woody plant species could be explained by the bioavailability of these MTEs resulting from intense gold panning activities and the use of chemicals such as cyanide, mercury at Komabangou. In addition, in a study evaluating the contamination level of some herbaceous species growing on mine site in the city of Kohatau in Pakistan, average concentrations measured in Cd, Cr, Zn, Cu and Pb are respectively 0.27 mg/kg; 0.696 mg/kg; 0.101 mg/kg; 0.696 mg/kg and 0.791 mg/kg (Nazir *et al*., 2015). Thus, despite the industrialization of Pakistan, these MTEs concentrations are lower than those obtained in herbaceous species growing at Komabangou site. However, measured MTE concentrations in woody species growing at Kohatau mine site in Pakistan are higher than those obtained in herbaceous species growing at Komabangou gold site

Conclusion

This study investigated the impact of gold mining at Komabangou area on plant species that develop there. The results showed that artisanal gold mining is a threat to plant biodiversity at Komabangou area. In fact, 261416 trees are destroyed for the strong support of all the functional wells identified at Komabangou gold site. To this high number of trees is added that of trees cut for the satisfaction of current needs (firewood, timber). The average concentrations of Co, Cu, Ni, Pb and Zn in herbaceous and woody species collected at Komabangou site showed an exceedance of standard values. This can be explained by the use of several chemicals during the various stages of gold mining, thus promoting the mobility and availability of metals. Also, these concentrations were very high in herbaceous species as in woody species. These results show that gold panning is a major problem given the enormous consequences that result, like desertification and pollution. However, these impacts are not limited to vegetation and could reach food chain. Toprotect environment and human health,it would therefore be necessary to limit not only the use of chemical substances but also the use of wood in the process of extracting gold at the Komabangou site.

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