Journal of Geology and Mining Research Vol. 3(4) pp. 87-104, April 2011
Available online http://www.academicjournals.org/jgmr
ISSN 2006-9766 ©2011 Academic Journals

Full Length Research Paper

Small scale mining and heavy metals pollution of agricultural soils: The case of Ishiagu Mining District, South Eastern Nigeria

Ezeh, H. N.* and Chukwu E.

Department of Geology and Exploration Geophysics, Ebonyi State University, P. M. B. 053, Abakaliki, Nigeria.

Accepted 17 January, 2011

This research assesses the distribution of Pb, Zn, Cu, Cd, Co and Ni in soils in Ishiagu. Mining has become prominent in this area because of existence of Pb – Zn lodes, veins and veinlets. It has thus become necessary to assess these because these metals are associated with Pb-Zn mineralization and are also significant in environmental health consideration, since they constitute priority pollutants. The concentration of Pb varies from 0.5 to 13671 mg/kg; Zn from 7.5 to 1460.5 mg/kg; Cu from 4 to 36.5 mg/kg; Cd from 0.5 to 10 mg/kg; Ni from 2 to 40 mg/kg and Co from, 0.5 to 146.5 mg/kg. Pb, Zn, Cd and Co attains toxic limit of 100, 300, 5 and 40 mg/kg respectively in the samples from Ugwu-Ajirija, Eziator, Amagu, Amaeze and Amokwe. The close proximity between the polluted areas and areas with history of mining is established. The source of these metals in soil is the mineralized vein, the mine dumps, the Asu River Shales and the minor basic intrusive. Mining of the Pb-Zn ores is responsible for the mobilisation of these metals into soil.

Key words: Heavy metals, pollution, soils, mining, Pb - Zn lodes, Asu River Shales.

INTRODUCTION

Soils constitute part of vital environmental, ecological and agricultural resource that has to be protected. The determination of elemental status of cultivated lands is necessary to identify yield limiting deficiencies of essential micronutrients and polluted soils (Alloway, 1990). This is especially important in Ishiagu because the inhabitants are essentially farmers, and large quantities of yams, rice and okro are produced, not only for local consumption, but also for food supplies to other parts of Nigeria. Mining has also become important because of existence of Pb-Zn lodes in the area.

The study focuses on the heavy metals Pb, Zn, Cu, Cd, Ni and Co. The potential for these to constitute pollutants in the area is high. Availability of these metals and the presence of factors capable of mobilising, distributing and storing them in pedologic system are critical. The metals have been implicated in various disease conditions in many other areas [Crounce et al., 1983; Thornton, 1983; Ferguson, 1990; Gerhat and Blomquist, 1992; Claridge et al., 1995; Essa, 1999; Miranda et al., 2005; Centeno et al., 2005]. The detailed documentation of disease prevalence has not been carried out in the study area. There are, however, concerns about the potential harmful effects of these metals in soils in the area. The assessment of the metals in the area is thus critical because of the following:

1. Pb, Zn, Cu, Cd, Ni, and Co form the major and minor elements of the Pb-Zn ores in the veins and lodes that abound in the area.
2. The Asu River Shales and minor basic and intermediate intrusive form the bedrock of the study area. They form therefore the essential bulk materials for soil formation.
3. The Asu River Shales are also enriched in trace metals [Kim et al., 1998; Thornton, 1983].

These metals are thus components of the existing rocks

*Corresponding author. E-mail: hilez2002@yahoo.com.

and mineralisation in the area. Some may have been absorbed from the ancient depositional environments [Obiora and Umeji, 1995].

Heavy metals in health and agriculture

Cadmium

This is a heavy metal of major environmental concern because of its high mobility and the small concentration at which it can adversely affect plants and animal metabolism. Furthermore it has adverse impact on soil biological activity [Kabata – Pendias and Pendias, 1984]. Cadmium is released as soluble Cd^{2+} ion during weathering. Under both acidic and alkaline conditions cadmium is adsorbed to surfaces of clay minerals, thereby reducing the mobility of the cadmium ions. Diet is the major source of cadmium intake because there is cadmium bio-accumulation in the food chain, especially in plants and seafood. Toxicity of cadmium results from cadmium substitution for zinc in enzymes [Stoessel, 2004]. The critical toxic endpoint after ingestion is kidney damage [Davies et al., 2005], because of bioaccumulation in the liver and kidney. Cd poisoning may result in the Cd substitution for Ca in bones producing itai itai, a degenerate bone disease.

Lead

Lead has an average range in soils of 17–26 g/kg [Stoessel, 2004]. It is the most immobile of all the common heavy metals. It is strongly sorbed by soils under neutral to basic conditions, being particularly attracted to sulphur groups in humans. Lead introduced at the soil's surface will complex with organic matter causing lead to be bound in the soil within the top few centimetres, where organic matter content is highest [National Environmental Policy Institute, 2000]. Lead poisoning has dominated the environmental agenda for several decades. Nonetheless, environmental lead remained a mere curiosity until the 1960s. Lead does not undergo biomagnifications in food chain and also not toxic to plants [Stoessel, 2004]. Some of the known effects on higher plants include dark green leaves, stunted foliage and increased amounts of shoots [Ferguson, 1990]. It is not known to be of any known function in the human body [Essa, 1999]. The inorganic forms of lead in soil have the same toxic endpoints [National Environmental Policy Institute, 2000]. The common symptom of lead poisoning is anaemia because lead interferes with the formation of haemoglobin. It prevents iron uptake [Stoessel, 2004]. High levels of lead may produce permanent brain damage and kidney dysfunction. Over time lead will substitute Ca in bone which acts to store the lead. Then in old age the lead is reactivated by slow dissolution of the bone.

Nickel

Agricultural soils contain Ni at levels of 8.5 – 15 mg/kg. Nickel exists in several oxidation states, but the divalent ion seems to be the most important for both organic and inorganic species. In soils, nickel may be present in a variety of forms. These include forms that are very limited in solubility (sulphide and sulphates) to the more soluble carbonate forms. The major source of nickel for humans is food where nickel can be present from normal intake from the soil. Nickel is considered likely to be an essential micronutrient [Calabrese et al., 1985]. Exposure to nickel toxicity produces a specific form of dermatitis and may include the lining and nasal cavity cancer.

Zinc

Zinc is an essential trace element for both animals and humans. It is usually present in the divalent state (Zn^{2+}). Many rocks and minerals contain Zn in varying amounts. Sphalerite (ZnS) is the most important mineral and the principal source of the metal. The distribution and transport of Zn in water, sediment and soil are dependent upon the species present and characteristics of the environment. Natural background of total Zn concentration is usually from 10 – 300 µg/kg dry weight in soils [Calabrese et al., 1985]. Increased levels can be attributed to natural occurrence of Zn-enriched ores, to anthropogenic sources or even through abiotic and biotic processes. A deficiency of zinc is marked by retarded growth, loss of taste and in the case of pre-pubertal males, hypo-gonadism and decreased fertility. Toxicity in human may occur if zinc concentration in water approaches 400 µg/l. This is characterized by symptoms of irritability, muscular stiffness and pain, loss of appetite and nausea. Zinc appears to have a protective effect against the toxicities of both cadmium and lead (Fergusson, 1990). Zn has been shown to exert adverse reproductive biochemical, physiological and behavioural effect on a variety of aquatic organisms as concentrations exceed 20 µg/l. Toxicity is however influenced by many factors such as the temperature, hardness and pH of the water [World Health Organisation (WHO), (2001]. Zn toxicity in plants generally causes disturbances in metabolism.

Copper

Anomalous Cu concentration in soils is generally from mineralization. Cu is very mobile in weathering environment [Mason, 1966]. This is the reason why it can hardly be found in excess in soils. What is generally experienced is Cu deficiency in soils. Copper has been found in all forms of animal and plant life and in every part of human body. It is an essential part of several

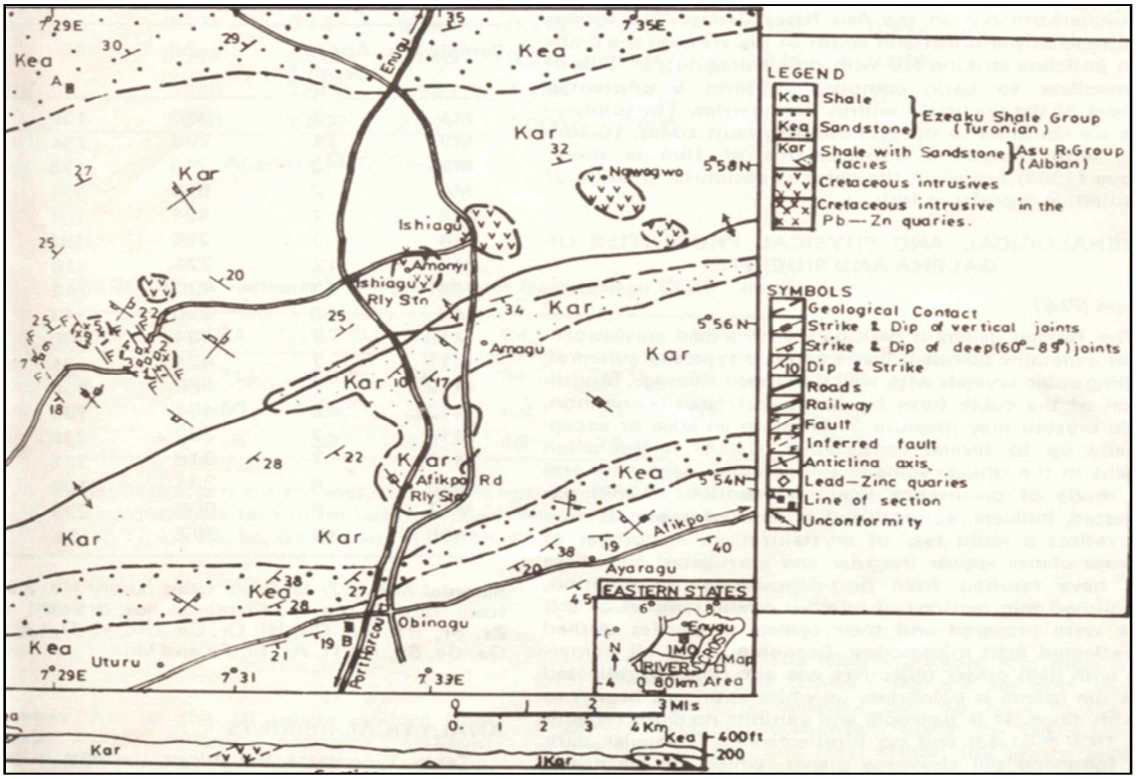

Figure 1. The geologic map of Ishagu Pb – Zn deposit (Ezepue, 1985).

enzymes and is essential for the synthesis of haemoglobin. Cu deficiency in soils can generally lead to serious reduction in yield in cereals [Thornton, 1983]. Cu deficiency in humans may cause anaemia, poor growth, degeneration of the nervous system and bone demineralisation leading to osteoporosis and bone fractures [Lech et al., 2004].

Medico-Regional studies: The Nigerian situation

Very little has been done in medico regional studies in Nigeria. More emphasis has been placed by the national government and international aid agencies and development banks on studies concerned with such issues as the quality of water resources, waste management, pollution related to mining, industrialisation or urbanisation, soil degradation as a result of salinization and deforestation.

The Nigerian situation calls for more concern. Researches in heavy element in the Nigerian environment have been scanty. They have been essentially concentrated on the local distribution of elements for the purpose of exploration for mineral deposits or routine investigations, in the activities of the Nigerian Geologic Survey Department. In Nigeria concerns for the environment are centred on natural and manmade hazards and their mitigation. Thus such hazards as floods, soil erosion, coastal and gully erosion, deforestation and oil pollution have continued to receive serious attention to the utter exclusion of other impacts on the environment such as diffuse pollution of soils, groundwater or even surface water. A number of workshops have been organised in the past to discuss the hazards and their mitigation.

Okunola [1993] in one of such workshops, made a case for the need for a regional appraisal of elemental distribution in Nigeria because it will provide basic and broad information related to the geological and geochemical affinities. Such regional appraisal he believes will provide useful guide to evaluating the pollution hazards based on the regional distribution of known geochemical anomalies. In the scheme he provided, the area of the present study belongs to the Pb-Zn zone. This zone he interprets as a zone of possible pollution of the surface environment by Pb, Zn and other related elements.

THE STUDY AREA

Location

The study area is located between latitude N5° 55´ and N6° 00´ and longitudes E7° 30´ and E7° 35´. The relief of the study area is low-lying and undulating. Figure 1

Plate 1. Mining activities at Ugwu Ajririja Lode.

shows the geology of the area.

Geology

The geology of the area comprises sequences of sandy shales, with fine grained micaceous sandstones and mudstones that is Albian in age and belongs to the Asu River Group (Figure 1). Generally they are dark coloured shales and mudstones. The dark coloured shales are believed to have formed in stagnant marine basins and are dark coloured because they contain sulphide minerals and large quantities of organic matter. The shales are often calcareous and pyritic. There are also lenses of sandstone and limestone. The rocks are extensively fractured, folded and faulted. There are several isolated minor basic and intermediate intrusive, which are thought to be sills [Ezepue, 1984].

Mineralisation

There are several Pb-Zn veins which are hosted by the gently dipping Asu River Shales. The fault zones are the main zones of mineralisation. The mineralisation is generally in open space filings of a series of steeply dipping fractures, which cut the regional fold axis of the Abakaliki Anticlinorium [Ezepue, 1984]. The sulphide rich veins are confined to NE – SW trending fault zones, 10 – 30 m wide. The dominant constituents of the veins are galena and sphalerite in a gangue of siderite. These sulphide minerals may constitute up to 15 vol. % of the veins, while siderite may represent up to 80% and quartz, 5% [Ezepue, 1984]. Galena is dark grey with grey streak. The galena often occurs as fine granular aggregates.

Mining in the area

The local population had worked these deposits for domestic uses. Since then, numerous mining companies have extracted some of the ores at one time or the other up to the present (Plate 1). Ishiagu has thus become a big market for galena and patronised by small scale traders who serve as agents for exporters and also provide stock to satisfy local needs. Because a lot of people had learnt one or two techniques of the mining process during periods of organised mining, when some mining companies worked in Ishiagu, individuals and groups have suddenly become involved. A lot of mining sites and pits have been opened in the area. This has provided a major source of income for the inhabitants. A major characteristic of the activity of these mining activities is that all processes of mining are done manually. Excavation is carried out manually. Galena are handpicked and most times what is picked are the granular types, leaving the more dispersed aggregates of galena, sphalerite and other associated minerals in tailings and wastes. Machinery is rarely employed. Tailings and mine waste are indiscriminately disposed. Other considerations for the environment are not made either because of ignorance, lack of fund or that consideration for maximisation of profit is more important.

Soils

Soils in the area comprise reddish brown gravely and pale clayey soils derived from shales and shallow pale brown soils derived from sandy shales. All the soils are residual. The red yellow soils are derived from the red and reddish-yellow earth formed by the weathering and subsequent ferruginisation of underlying sandstone units, the shales and igneous rocks which form the bedrock.

Objectives of the study

1. To establish the distribution patterns of Pb, Zn, Cu, Cd, Ni and Co in soils in the area.
2. Assess the pollution status of soils by comparing their metal concentration with established standards.

METHODS

Sampling was done on a grid of approximately 1000 m. They were picked from the bottom of holes about 15 cm deep deliberately made by use of picks and cutlasses. This depth was believed to be sufficient for characterising cultivatable top soil. About 100 g of fine fractions was put in a polyethylene bags and labelled. Gamin eTrex GPS was used to locate each sample point by recording the Easting and Northing of that point. A total of 26 samples were collected. The samples were dried, homogenized and passed through 100 mesh nylon screen. The samples were digested by use of aqua regia. The aliquot was analysed by use of Buck Scientific Atomic Absorption Spectrometer 205 for Pb, Zn, Cu, Cd, Ni and Co in the laboratories of Ideyi Consults, Port Harcourt, Nigeria. The surfer 32 Surface Mapping System file version 6.2.0.22 from Golden Software Inc., was used to grid and contour the data

Table 1. The concentration of Pb. Zn, Cu, Ni, Cd and Co in soils in Ishiagu.

Sample location	Easting	Northing	Elevation	Pb	Zn	Cu	Ni	Cd	Co
Ugwuajirija I	334489	662216	80	1573.5	1070	36.5	17.5	5.5	39
Ugwuajirija II	336229	660368	84	13671	1460.5	13	17	10	47
Amonye I	334484	660373	75	21	30	6	6	0.5	0.5
Amonye II	334480	658530	83	19.5	36.5	6	12	<0.5	10
Eziator	336225	658525	65	782	992.5	31.5	40.5	7	78
Amaeze I	338070	658521	66	1	48	7.5	17.5	<0.5	16
Amaeze II	339915	658516	60	32	180.5	10	7.5	1	13
Amagu I	341764	658571	48	128	64.5	7.5	13.5	0.5	14
Amagu II	341769	660354	53	22	27.5	10	15	<0.5	11
Amagu III	341774	662197	57	26.5	17	7.5	11	0.5	7.5
Ihie I	339925	662201	64	15	43.5	5	11.5	1.5	9
Ihie II	338079	662206	69	22.5	30	13.5	14	1.5	18.5
Ngwogwo I	336234	662211	72	12	19.5	4	11.5	1	3
Ngwogwo II	338074	660363	56	12	34.5	5.5	9	1.5	3.5
Ngwogwo III	339920	660358	70	18.5	32	9.5	15	1.5	16
Okwe I	341759	656668	79	90.5	32.5	10.5	19	1.5	12.5
Okwe II	341755	654824	82	16	81	13.5	23	3	30
Amagu/Ogwo I	339906	654829	61	11	21.5	5	10	1.5	3.5
Amagu/Ogwo II	338060	654834	55	30.5	52	10	18	2	15
Amagu/Ogwo III	336215	654839	73	16.5	60	10.5	22.5	1.5	12.5
Ishiagu I	334375	656688	75	9	44	9	13	2	12
Ishiagu II	336220	656683	64	<0.5	7.5	5.5	2	<0.5	3
Amaokwe I	338065	656678	83	52	67.5	30.5	39.5	3.5	146.5
Amaokwe II	334370	654843	59	9	13.5	8.5	14.5	1	10.5
Amaokwe III	337658	657898	61	29	45.5	13	29.5	2.5	27
Range				<0.05 – 13671	13.5 – 1460	4.00 – 36.5	2.00 – 39.5	<0.05 – 10.00	0.05 – 146.5
Mean				640.25	175.29	11.46	16.38	2.5	22.37
Normal soil [25].				35 mg/kg	90 mg/kg	30 mg/kg	15 mg/kg	0.35 mg/kg	-
Tolerable level [14]				100 mg/kg	300 mg/kg	100 mg/kg	100 mg/kg	3 mg/kg	40.5 mg/kg

generated from the field and laboratory.

RESULTS

The result of analyses for Pb, Zn, Cu, Cd, Ni and Co in soils from Ishiagu is shown in Table 1. Figures 2 to 7 are the contour maps of the distribution of Pb, Zn, Cu, Cd, Ni and Co respectively. The range of concentration of Pb in the samples is from <0.05 to 13671.00 mg/kg, with a mean of 640.25 mg/kg. The maximum concentration is 13671.00 mg/kg, and recorded at Ugwuajirija; the minimum is 0.5 mg/kg. Zn concentration in soils ranges from 13.5 to 1460.50 mg/kg, with a mean of 175.29 mg/kg. The minimum concentration of 13.5 mg/kg was recorded at Amaokwe; while the maximum of 1460.5 mg/kg

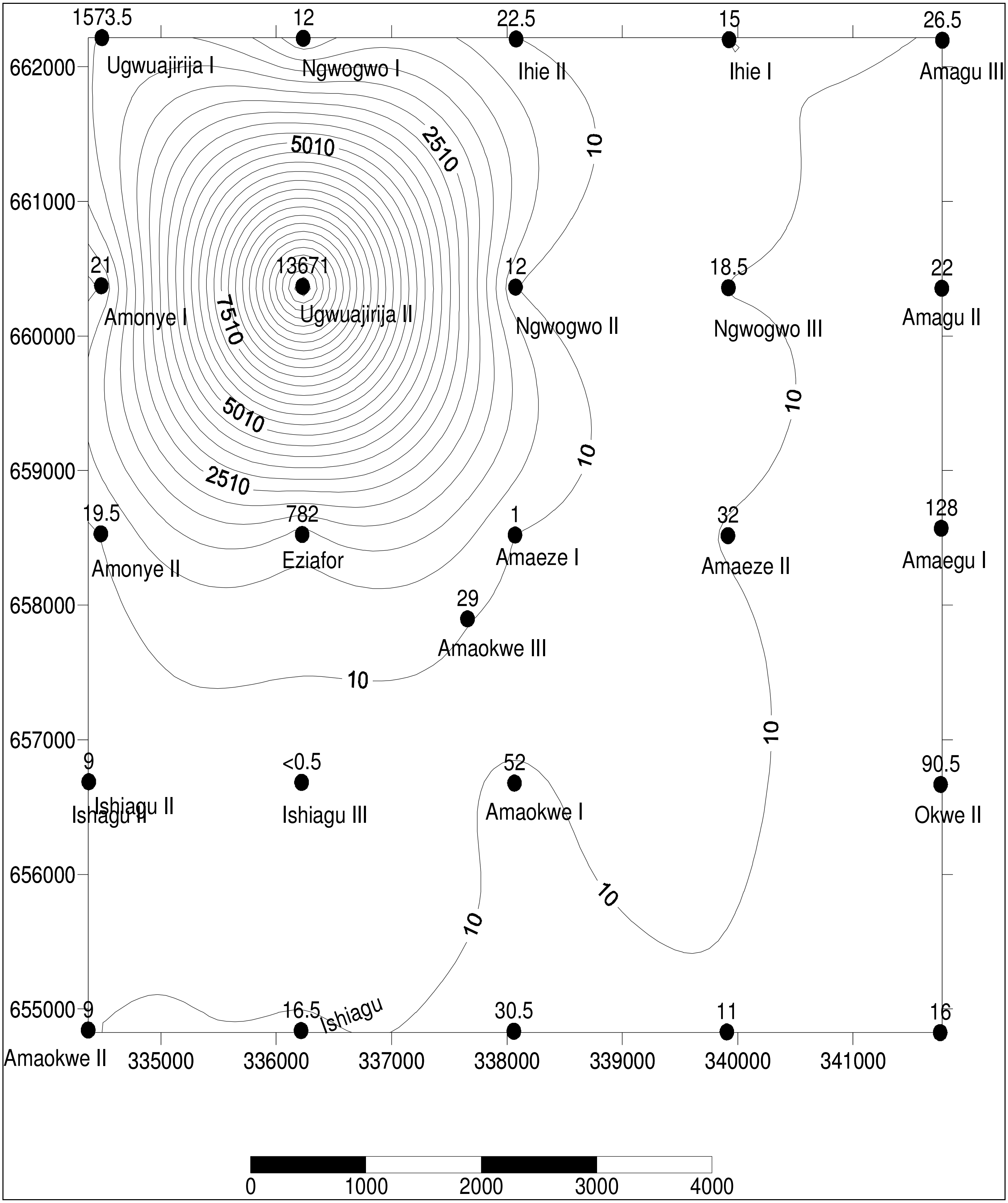

Figure 2. The contour map of distribution of Pb in soils in Ishiagu.

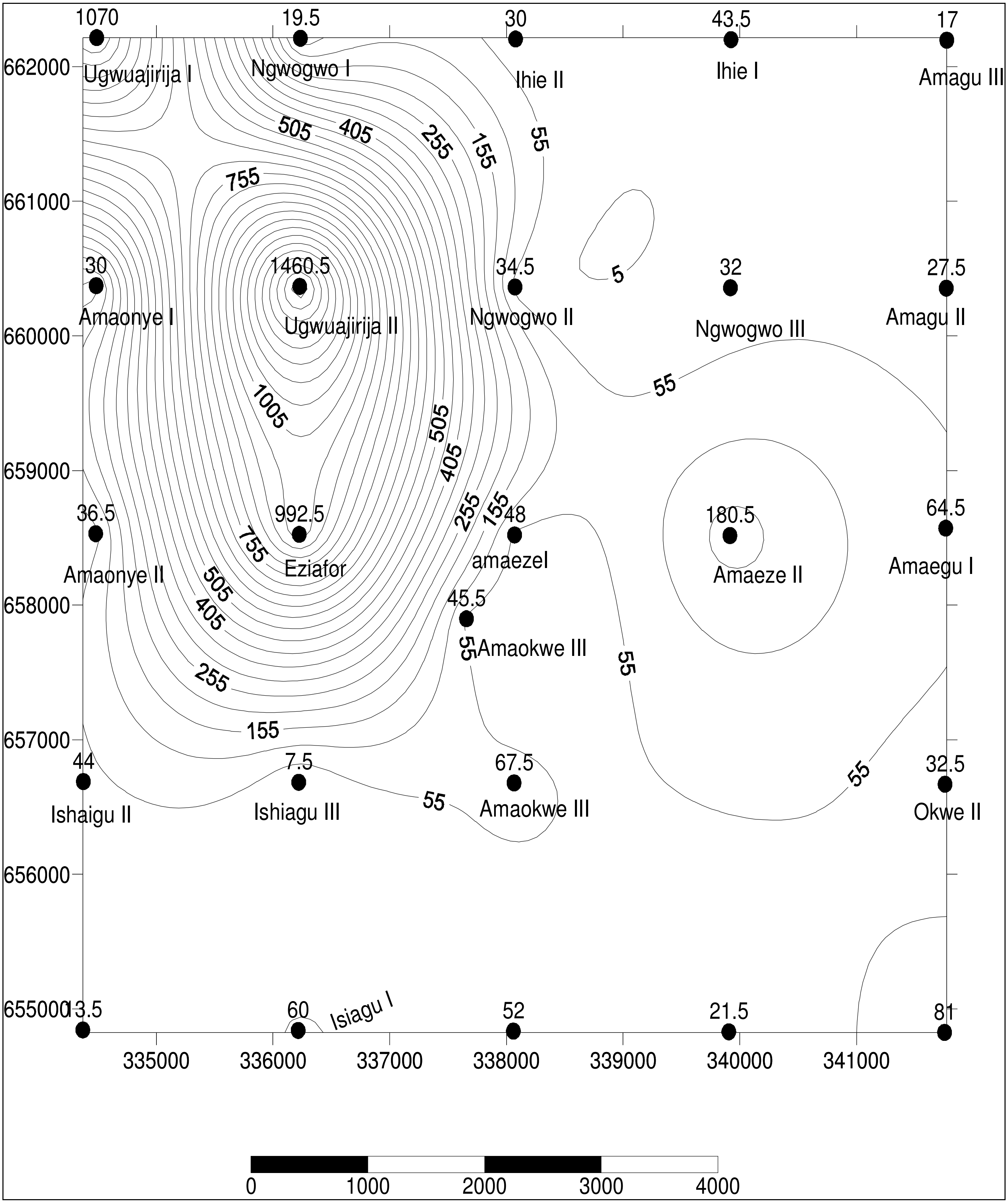

Figure 3. The contour map of distribution of Zn in soils in Ishiagu.

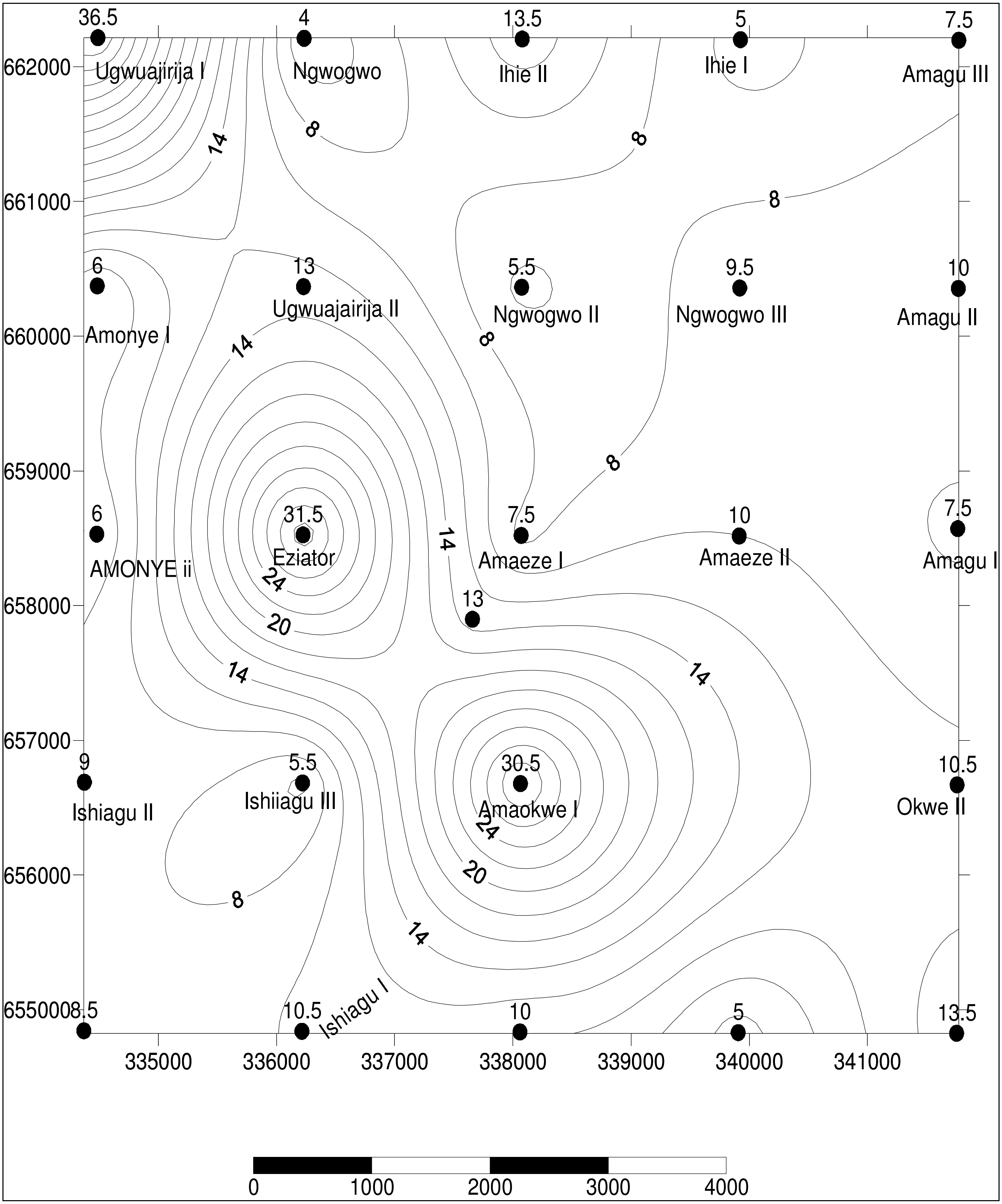

Figure 4. The contour map of distribution of Cu in soils in Ishiagu.

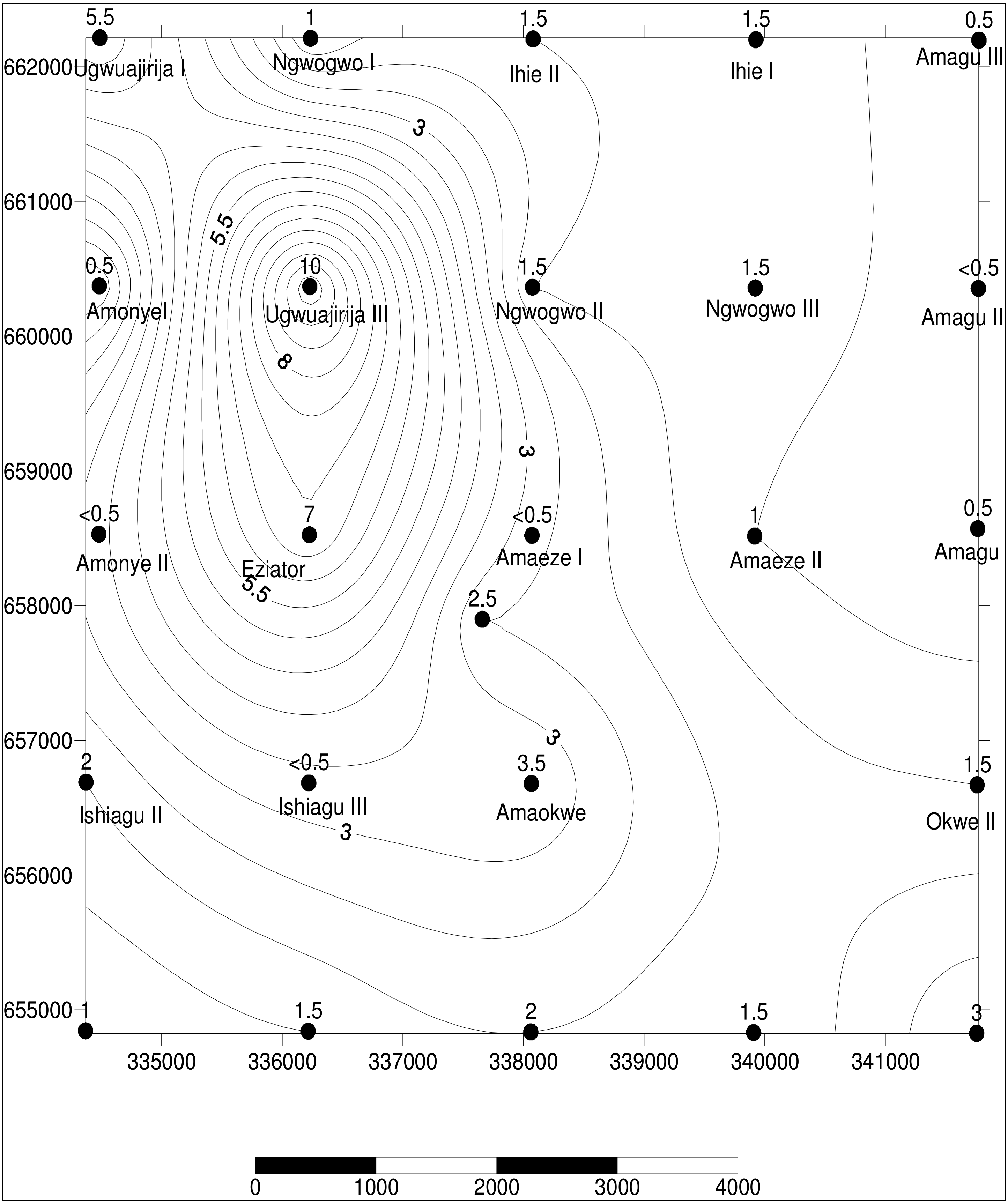

Figure 5. The contour map of distribution of Cd in soils in Ishiagu.

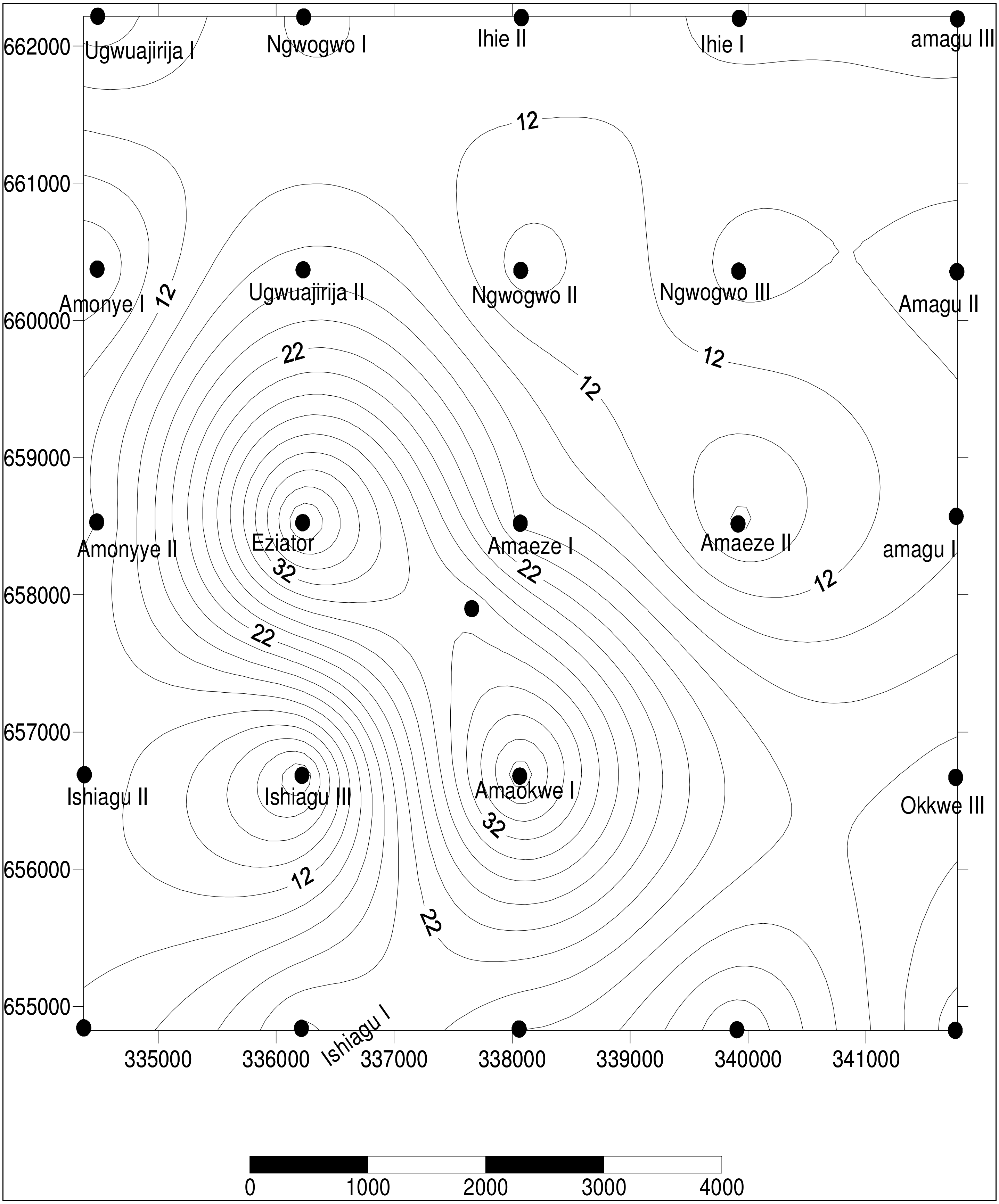

Figure 6. The contour map of distribution of Ni in soils in Ishiagu.

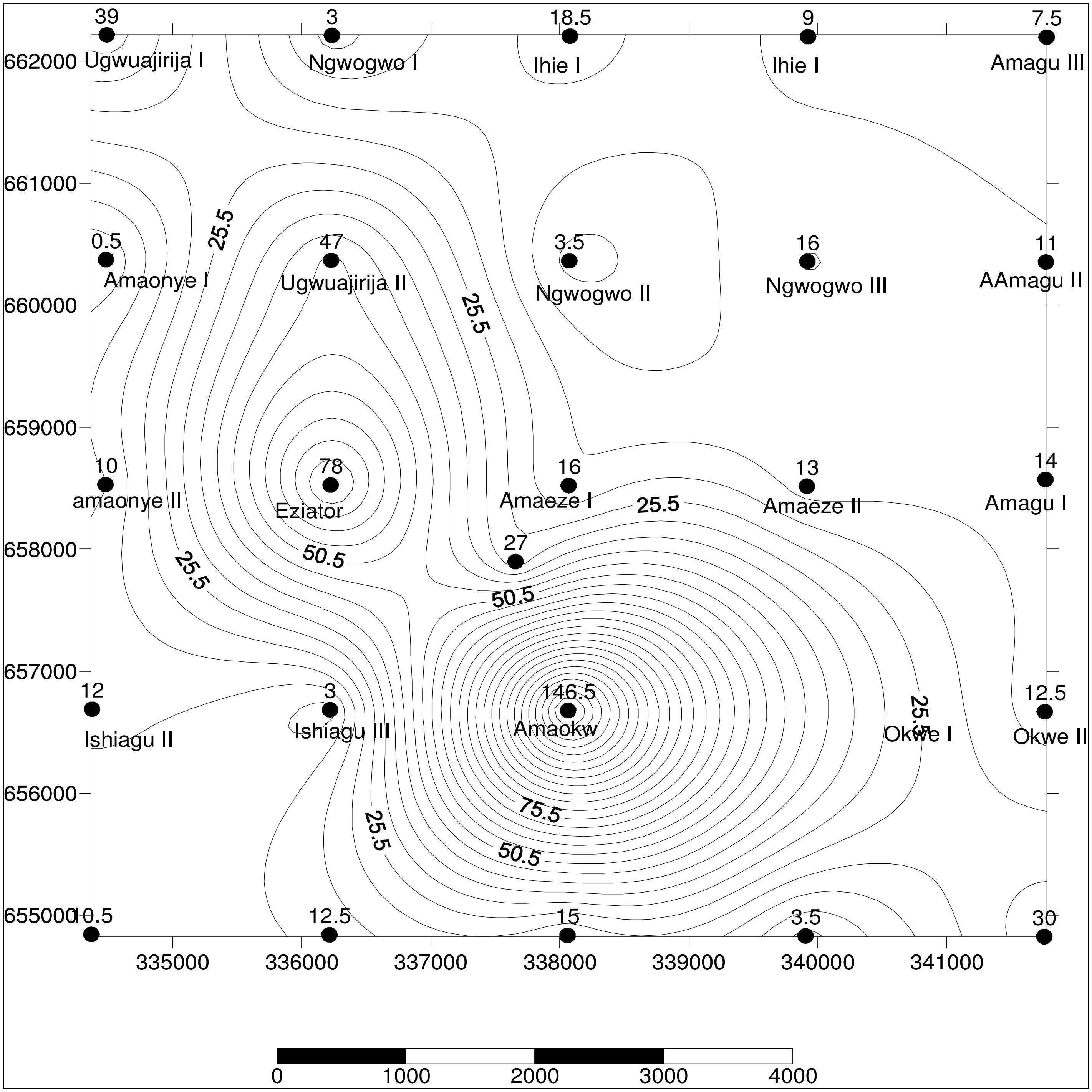

Figure 7. The contour map of distribution of Co in soils in Ishiagu.

was recorded at Ugwuajirija. The range of concentration of Cu in the samples is from 4.00 to 36.5 mg/kg, with a 36.5 mg/kg was recorded at Amonye. The concentration of Cd varies from <0.05 mg/kg in Amaeze and Ishiagu to 10.00 mg/kg in Ugwuajirija, with a mean of 2.5 mg/kg. The range of concentration of Ni is from 2 to 39.5 mg/kg, with a mean of 16.58 mg/kg. The minimum Ni mean of 11.46 mg/kg. The minimum concentration of 4 mg/kg was recorded at Ngwogwo; while the maximum of concentration of 2 mg/kg was recorded at Ishiagu; while the maximum of 39.5 mg/kg was recorded at Amaokwe. The range of concentration of Co is from 0.5 mg/kg in Amonye, to 146.5 mg/kg in Amaokwe, with a mean of 22.37 mg/kg.

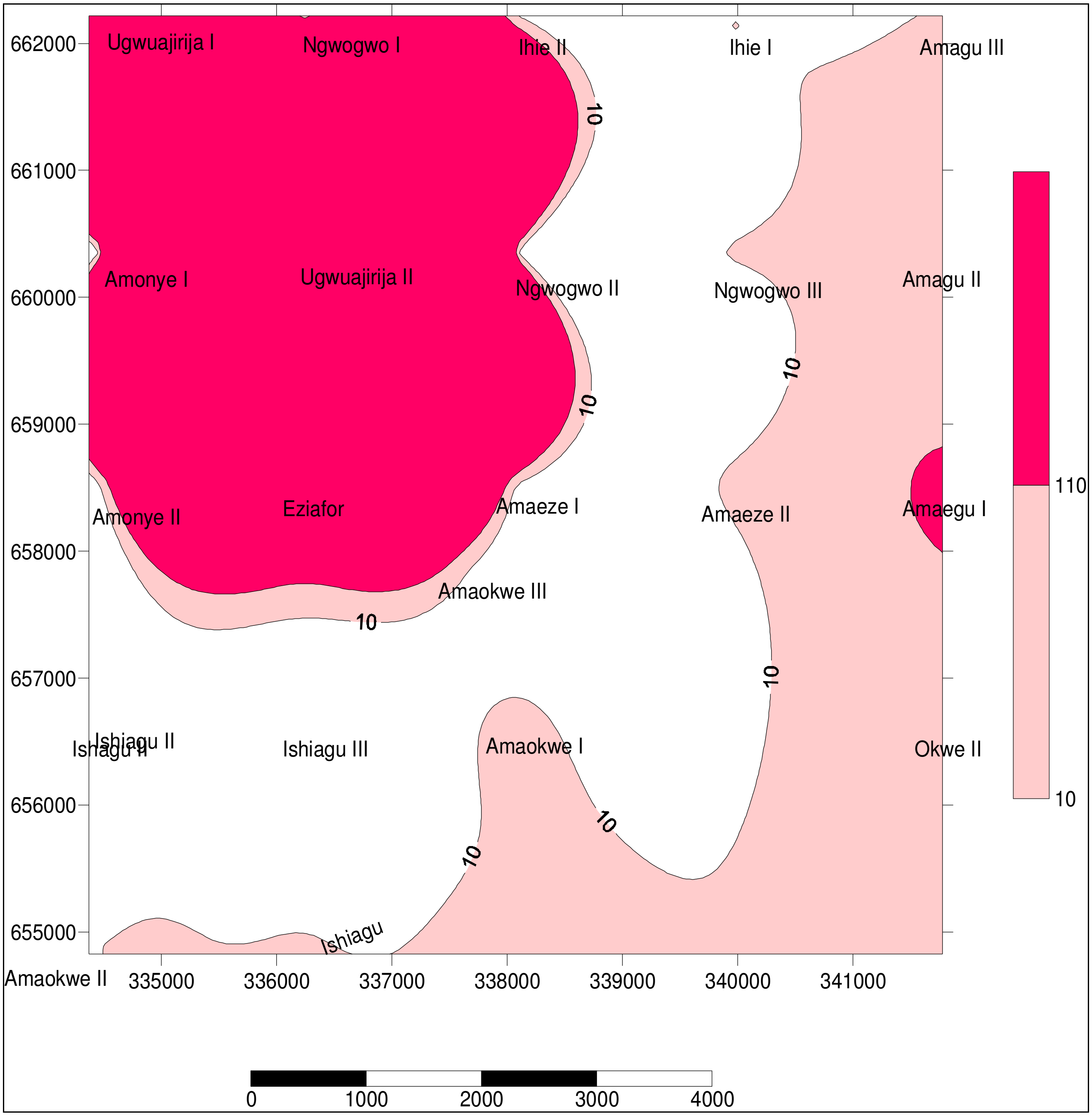

Figure 8. Map of Ishiagu showing areas of Pb pollution (coloured red).

DISCUSSION

The pollution status of soils in Ishiagu

The tolerable limits set by various established standards for the analysed metals in soils are shown in Table 1. As shown the tolerable concentrations of Cu, Pb, Zn, Cd, Ni and Co in normal soils are Cu, 30 mg/kg; Pb, 35 mg/kg; Zn 90 mg/kg; Cd, 3 mg/kg; Ni, 30 mg/kg; and Co, 40 mg/kg [Bowen, 1979]. These are generally lower than the levels proposed by Kabata Pendias and Pendias, [1984], which are now more widely accepted. In this work the tolerable limits by Kabata – Pendias and Pendias [1984], will be adopted because of wide usage in quality assessment of agricultural soils. The estimated toxic levels in soils for purposes of agriculture are: Cu, 60 mg/kg; Pb, 100 mg/kg; Zn, 70 mg/kg; Ni, 100 mg/kg; Co, 35 mg/kg; Cd, 5 mg/kg.

Figures 8 to 11 are the maps of the areas with concentration of metals above toxic levels of individual

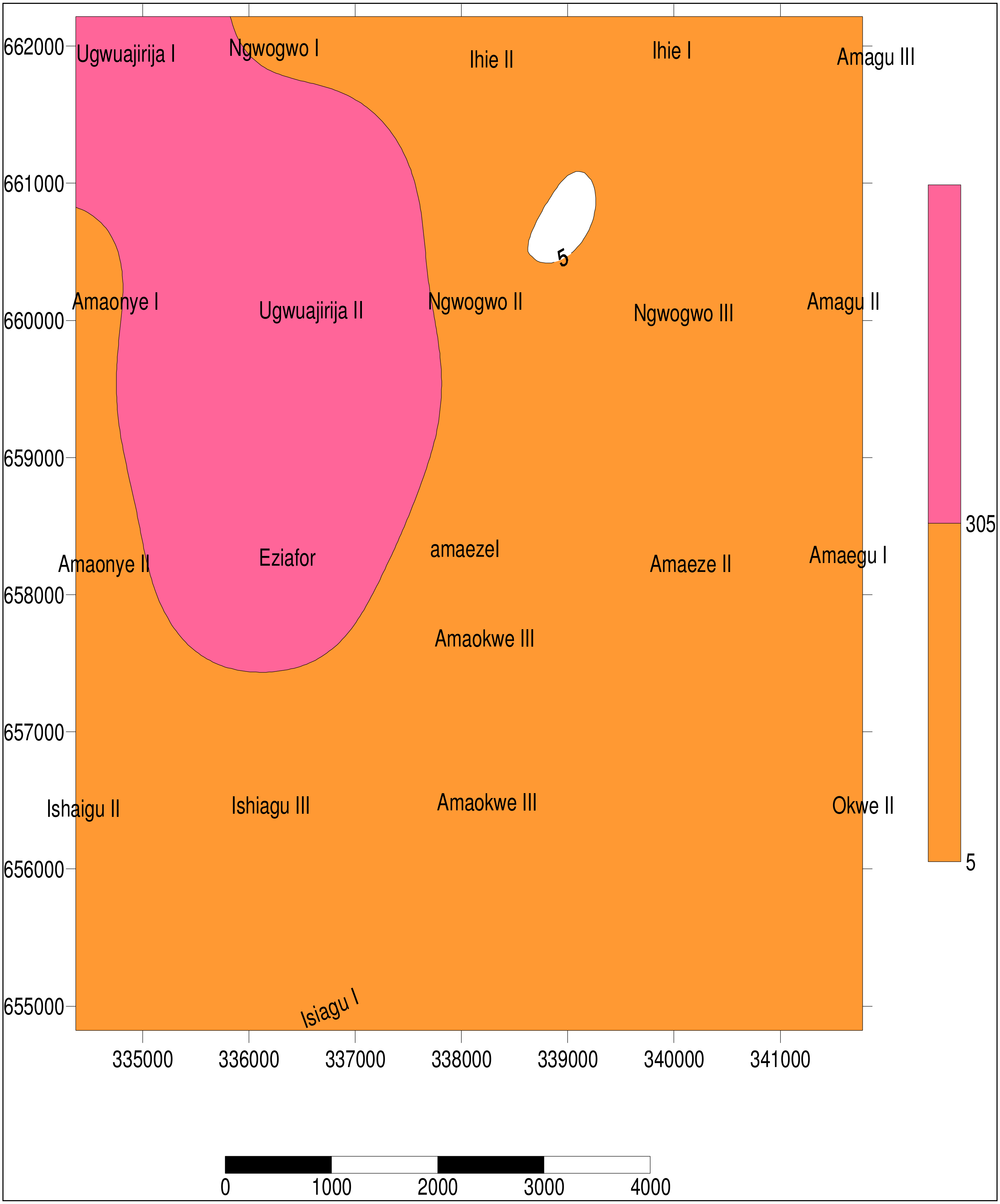

Figure 9. The map of Ishiagu showing areas of Zn pollution (coloured red).

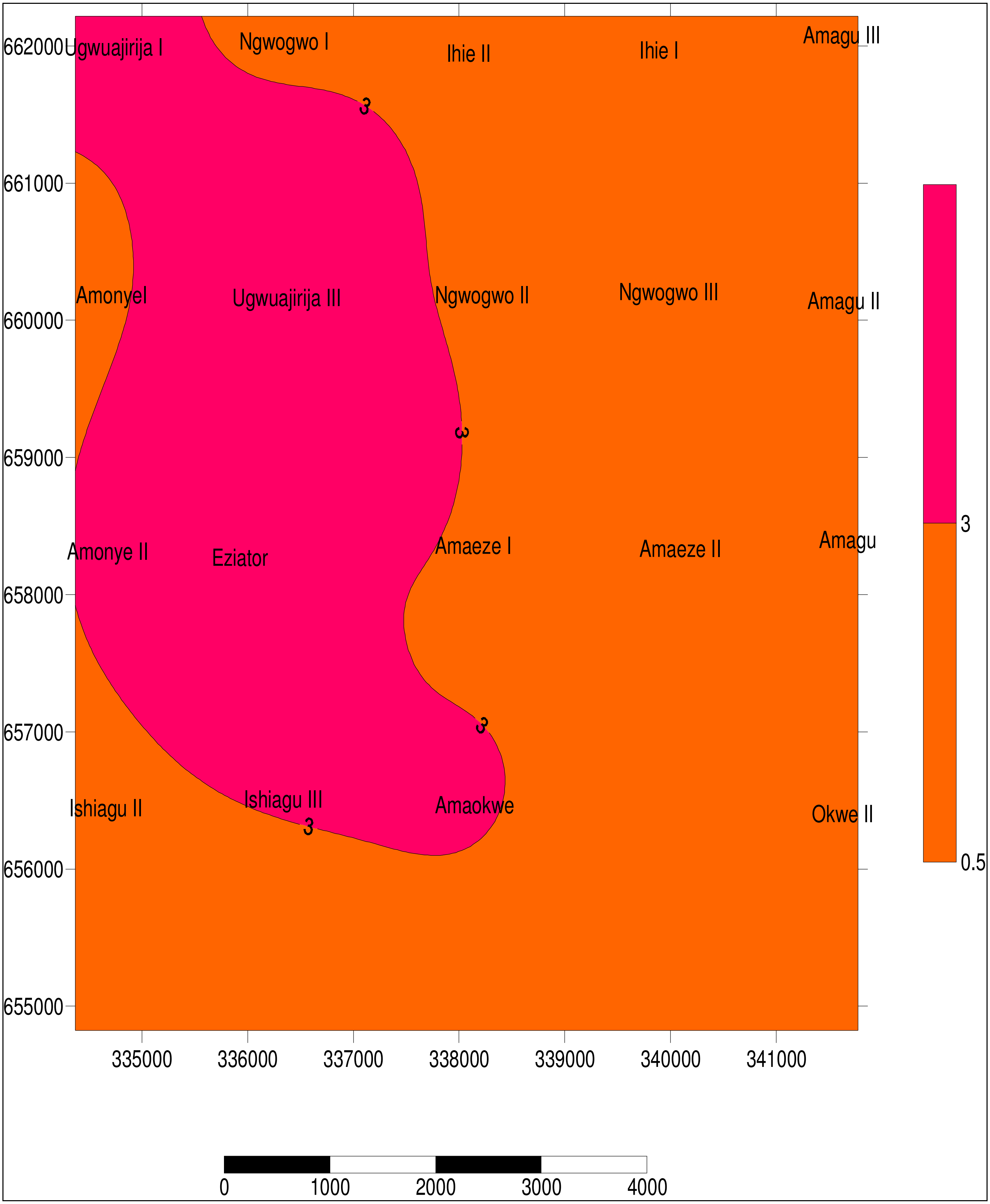

Figure 10. Map of Ishiagu showing areas of Cd pollution (coloured red).

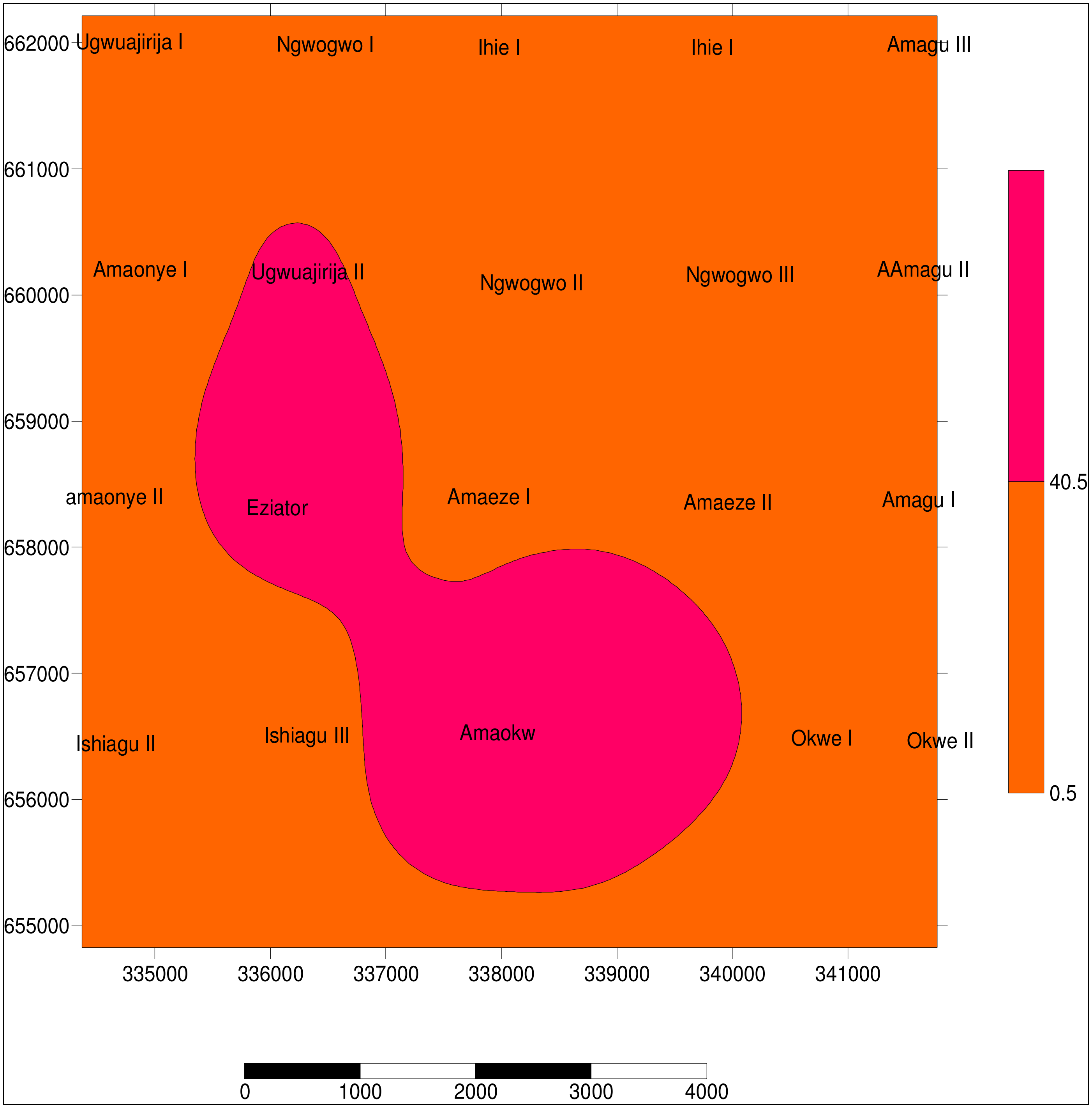

Figure 11. Map of Ishiagu showing areas of Co pollution (coloured red).

metals, that is, polluted areas (shown in red).

The concentration of copper in soil is below toxic level in all samples analysed. In some areas the soil could be described as being deficient in Cu since concentration is below 20 mg/kg according to Thornton and Webb [1979]. Cu is very mobile in weathering environment [Mason, 1966]. This is the reason why it can hardly be found in excess in soils. The concentration of Pb in soils in Ishiagu tends to be higher than for the normal soil. The concentration attains toxic levels in a number of areas e.g. Ugwajirija between 1573 and 13671 mg/kg; Eziator 782 mg/kg and Amagu 128 mg/kg; measures that are 15 – 137, 8 and 1.3 folds higher than the standards respectively (Figure 8). This level of Pb in the areas is

Plate 2. Mining Tailings trailing parallel to mined out lode in Ugwu – Ajirija.

attributable to releases from the mine dumps around Ugwuajirija and Eziator, concealed Pb – Zn lodes as well as from bedrock. The bedrocks of black shales and basic intrusive could contain high concentrations of trace metals including Pb [Thornton, 1983]. Pb is also known to adsorb to onto soil constituents surfaces such as clay, oxides, hydroxides and organic matter. Adsorption processes is relevant in the area because of the clayey and ferraltic nature of the soils. The distribution of zinc in the area attains toxic levels in soil samples from Ugwuajirija and Eziator. Zinc, though an important metal for health of plants and animals could be regarded as a contaminant in Ugwuajirija and Eziator because of level of concentration of this metal (1070-1460 and 992.5 mg/kg respectively Figure 9). Zinc which is very mobile in weathering environment could have accumulated in soils apparently because of carbonate materials that encourage zinc precipitation [Lee et al., 1998]. Cadmium concentration in soils attains toxic level at Ugwuajirija 5.5 – 10 mg/kg and Eziator 7 mg/kg (Figure 10). In Amaokwe and Amagu/Ogwor the toxicity level is marginal. Cadmium is more mobile than Pb because it is weakly sorbed and is not retained in soils through cation exchange [Sparks, 2005; Ferguson, 1990; Adriano, 1986]. It also does not form stable methyl compounds. The concentration of Ni in all samples is below toxic level. This is because Ni is easily mobilised during weathering [Kabata–Pendias and Pendias, 1984]. Co concentration attains toxic levels only at Ugwuajirija (39 – 47 mg/kg) and Eziator (78 mg/kg Figure 11).

Sources of metals

In the area of study, industrial practices as sources of heavy metal pollution are insignificant. Since manufacturing industry is not developed and agricultural practice low, the source of metals in the soil cannot be industrial or agricultural. However in assessing the sources of heavy metals in soil in the area, the following have to be noted:

1. The inhabitants of the study area are engaged in subsistence agriculture. A major characteristics of this type of agricultural practice is that there is no extensive application of technologies e.g. fertilizers.
2. Manufacturing industry is not developed
3. The inhabitants of the area are engaged in mining because of existence of Pb – Zn lodes in the area. The mine tailings are indiscriminately disposed.

The sources of the metals are geologic materials which include the following, that is, the Asu River Shales, the minerals veins and the mine tailings.

The Asu River Shales

These had earlier been discussed. Though the major and minor elements composition of these Shales have not been reported, it is agreed that these Shales which outcrop in the area are enriched with heavy metals especially with Cu, Ni, Pb and Cd like in other black shales in other parts of the world e.g. in Korea [Lee et al., 1998; Davies, 1983]. Our work on Enyigba, another mining district reveals high level pollution of soil by Pb snd Cd [Ezeh, 2007; Ezeh et al., 2007]. Weathering and podzolisation release these metals into the soil.

The mineral veins

Pb – Zn mineralization is abundant in the area. The dominant constituents of the veins are galena (PbS) and sphalerites (ZnS) in gangue of siderite ($FeCO_3$), with subordinate chalcopyrite ($CuFeS_2$) and marcasite (FeS_2) [Kabata–Pendias and Pendias, 1984]. There is widespread isomorphism in these minerals [Smirnov, 1982]. Ni – Fe isomorphism in pyrite and chalcopyrite, Cd – Zn isomorphism in sphalerites and As – S isomorphism in chalcopyrite are well known.

The mine tailings

In Ishiagu, mine tailings are indiscriminately dumped. Sometimes these dumps are noticed as elongate ridges trailing and parallel to mined out veins (Plate 2). These tailings have become important materials for soil formation. In these tailings are contained the same minerals of the ore and gangue, which like the mineral veins on weathering releases into soils the composing metals. Similar situations also exist in the Mininig District of Enyigba, where we documented existing soil pollution.

The position that the above named geologic materials are the sources of the metals in the soil in the area is further strengthened by the fact that the anomalies as recorded in the analyses of soil are close to mineralized areas of Ugwuajirija and Eziator. These areas too have history of mining of Pb – Zn ores. The strength of the anomalies got reduced, away from these areas.

Besides these, further controls on the metals distribution are the ferraltic nature of the soils, mobility of the metals and the membrane effects of the shales and clays. Other controls that arise from human activities include bush burning. This releases the heavy metals contained in leaves and tissues in plants into soils [Olade, 1987].

The role of small scale mining

As mentioned, the inhabitants of Ishiagu are farmers but mining has however become prominent because of existence of numerous lodes, veins and veinlets in the area. These small scale miners expose the geological materials (the shales, the intrusive and the ores), which are the sources of these heavy metals, to intensive weathering. Intensive weathering is aided by heavy rainfall and undulating relief. Exposure and /or mining thus predispose these minerals to weathering, making them break down chemically or mechanically. This releases these composing metals into soil either as aqueous species or in dispersed forms of the constituting mineral or as precipitates of new minerals.

Conclusion

This study reveals a case of pollution of soils by heavy metals around Ugwuajirija and Eziator areas of the mining district of Ishiagu. The polluting metals are Pb, Zn, Cd and Co. The source of these metals is geologic materials which include: the Asu River Shales, the Pb Zn lodes, the minor basic and intermediate intrusives and the mine tailings. Activities related to mining exposes these materials to intensive weathering, aided by twin factors of heavy rainfall and undulating relief. These help in the mobilisation of the metals. Soil is specially predisposed to these mobilised metals because they are clayey and ferraltic.

REFERENCES

Adriano DC (1986). Trace Elements in Terrestrial Environment. Springer Verlag, Berlin, p. 533.

Alloway BJ (1990). Heavy Metals in soils. Blackie Glasgow, UK.

Bowen HJM (1979). Environmental Geochemistry of the Elements. Academic Press, London.

Calabrese EJ, Canada AT, Sacco C (1985). Trace Elements and Public Health. Annu. Rev. Pub. Health, 6: 131-146.

Centeno JA, Millic FG, Finkleman RI, Sellinus O (2005). Medical Geology. Military Med. Technol. Online, 9(5): 1–5.

Claridge GGC, Campbell IB, Powell HKJ, Amin ZH, Balks MR (1995). Heavy metal contamination in some soils of the McMurdo Sound Region, Antarctica. Antarctica Sci., 7(1): 9–14.

Crounce RG, Pories WJ, Bray TJ, Manger RL (1983). Geochemistry and man: Health and Disease. 2. Elements possibly essential, those toxic and others in Thornton, I. (ed.): Academic Press, London. Appl. Environ. Geochem., pp. 309–330.

Davies BE (1983). Heavy metal contamination from Base Metal Mining and Smelting, implications for man and his environment in Thornton, I. (ed.): Academic Press, London. Appl. Environ. Geochem., pp. 425–459.

Davies BE, Bowman C, Davies TC, Sellinus O (2005). Medical Geology: Perspectives and prospects. Essent. Med. Geol., Elsevier Inc., pp. 1-14.

Essa KA (1999). Lead, the ugly trace element, effects, screening and treatment. East. Medit. Health J., 5(4): 798–802.

Ezeh HN (2007). Environmental Significance of Heavy Metals Distribution in the Ebonyi River Drainage System, Abakaliki and Ohaozara Areas, South Eastern Nigeria. Ph.D. Thesis, Nnamdi Azikiwe University, Awka, Nigeria, p. 214.

Ezeh HN, Anike OL, Egboka BCE (2007). The Distribution of some Heavy metals in soils around the Derelict Enyigba Mines and its implication. J. Curr. World Environ., Bhopal India. 2(2): 99–106.

Ezepue MC (1984). The geologic setting of lead–zinc deposits at Ishiagu, South Eastern Nigeria. J. Afr. Earth Sci., 2: 97–101.

Ferguson JE (1990). The heavy Elements: Chemistry, Environmental Impact and Health Effects. Pergamon Press, London, p. 614.

Gerhat JM, Blomquist JD (1992). Selected trace elements and organic contaminant in streambed sediments of the Potomac River Basin. U.S. Geological Survey USGS, Water Resour. Investig, Rep., 95(4267): 1–12. http://geoweb.tamu.edu/courses/geol641/docs/metalabioavailability.pdf.

Kabata–Pendias A, Pendias H (1984). Trace elements in soils and plants. 3rd edition. CRC, Press, Boca Raton, p. 315.

Kim KW, Myung JH, Ahn JS, Chon HT (1998). Heavy metals contamination in dusts and stream sediments in the Taejon Area, Korea. J. Geochem. Explor., 64: 409–479. Elsevier.

Lech M de Caritat P, Jairet S, Pyke J (2004). Prliminary geohealth implication of the Riverina Geochemical survey in Roch, I.C. (ed.) Regolith. CRC Leme, pp. 204–208.

Lee J Chon H, Kim J, Moon H (1998). Enrichment of potentially toxic elements in areas underlain by black shales and slates in Korea. Environ. Geochem. Health, 20: 133–147.

Mason B (1966). Principles of Geochemistry. 3rd Edition, John Wiley and Sons, New York, p. 328.

Miranda M, Lopez-Alonso M, Castillo C, Hernandez J, Benedito JL (2005). Effects of moderate pollution on toxic and trace metal levels in calves from a polluted area of northern Spain. Environ. Int., Elsevier, 31: 343–348.

National Environmental Policy Institute (2000). Assessing the Bio availability of metals in Soil for Use in Human Health Risk Assessments, Metal Task Force Report.

Obiora SC, Umeji AC (1995). Alkaline Intrusive and Extrusive Rocks from Areas around Anyim River, S.E. Benue Trough. J. Min. Geol., 31(1): 9-19.

Okunola OA (1993). Geochemical Anomalies as potential Natural Hazards Instigators, perspective for a National Appraisal in Nigeria. Proceedings of The International Workshop on Natural and Man Made Hazards in Africa, Awka, Nigeria. From Jan. 31 – Feb. 3 1993. NMGS, pp. 184-198.

Olade MA (1987). Dispersion of Cd, Pb and Zn in soils and sediments of a humid tropical ecosystem in Nigeria. In T.C. Hutchinson (Ed): Lead, Mercury, Cadmium and Arsenic in the environment. John Wiley and Sons Ltd., pp. 303-313.

Smirnov VI (1982). Geology of Ore Deposits (the Russian language edition: Geologia Poleznikh Iskapaemikh). Moscow, NEDRA., p. 669.

Sparks DL (2005). Toxic metals in the environments: The role of surfaces. Elements, 3: 193–197.

Stoessel R (2004). Environmental Geochemistry notes of Ron Stoessel http://www.ronstoessell.org/environmental geochemistry.htm.

Thornton I (1983). Geochemistry Applied to Agriculture in Thornton (ed.): Academic Press London. Appl. Environ. Geochem., pp. 231–263.

Thornton I, Webb JS (1979). Geochemistry and Health in the U.K. Trans. Royal Soc. London, B(288): 151–168.

World Health Organization (WHO) (2001). Environmental Health Criteria. Zinc, p. 221.

World Health Organization (WHO) (2001). Environmental Health Criteria. Arsenic and Arsenic Compounds, p. 224.