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Full Length Research Paper

Soil-plant heavy metal relations and transfer factor index of habitats densely distributed with *Citrus reticulata* (tangerine)

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ABSTRACT

Field study to investigate the concentrations of some heavy metals in orchards located within the urban and rural parts of Uyo Local Government located of Akwa Ibom State State. Soil and fruit samples from the fruit farms were collected and prepared using standard analytical procedures and analytical grade reagents were used for digestion. A flame type atomic absorption spectrophotometer (AAS) was used for the analysis of six heavy metal (Zn, Pb, Cd, Cr, Mn and Fe) content of these samples. The result of the analysis of the soil samples from the urban and rural orchards yielded the following mean concentrations: Zn, 26.4 and 14.4mg/kg; Pb, 16.1and 10.8mg/kg; Mn, 54.3 and 52.9 mg/kg; Fe, 1013.0 and 143.0mg/kg; Cd, 4.4 and 3.7mg/kg and Cr, 13.9 and 11.8mg/kg respectively. The mean concentrations for fruit samples from the urban and rural orchards yielded the following mean: Zn, 16.4 and 5.4mg/kg; Pb, 2.6 and 0.80mg/kg; Cr,8.0 and 5.2 mg/kg; Mn, 22.7 and18.1mg/kg; Fe, 332 and 352 mg/kg and Cd, 2.6 and 1.0 mg/kg. These results showed that the concentrations of the metals in samples are comparatively higher for samples from urban orchards than those from rural orchards with the exception of Fe. The concentrations of Cadmium at both sites were least while Iron was the greatest. The differences in heavy metal profile of the orchards in the result could be attributed to the refuse constituent, high anthropogenic activities and disparities in soil properties leading to the accumulation of the metal ions in the soil and subsequent translocation into plants. Also, the concentrations of the investigated metals in the two sites were found to be within their permissible range in soil and could be said to pose no immediate toxic threat to man or the crop that might be planted on the soil collected from these sites. Some Recommendations on the proper handling of wastes to reduce possible toxic metal loads at dumpsites have also been highlighted.

Keywords: Soil-plant, transfer factor, heavy metal and *Citrus reticulata*

INTRODUCTION

Heavy metals are elements having atomic weight between 63.545 and 200.5 g and a specific gravity greater than four. The elements play essential roles in biological processes, but at higher concentrations they may be toxic to the biota and they disturb the biochemical processes and cause hazards. These elements include metals (Cd, Hg, Cr, Co, Cu, Zn, Pd, Ni, and Ag) and metalloids(Se, As, Sb). Most of the trace elements are transition metals with variable oxidation states and coordination numbers. These metals form complexes with organics in the environment thereby increasing their mobility in the biota and manifest toxic effects (Narayanan, 2009)

Heavy metals have been reported to have positive and negative roles in human life. Some like Cadmium (Cd), lead (Pb) and mercury (Hg) are major contaminants of food supply and may be considered the most important problem to our environment while others like iron (Fe), Zn and Cu are essential for biochemical reactions in the body. Generally, most heavy metals are not biodegradable, have long biological half-lives and have the potential for accumulation in different body organs leading to unwanted side effects. The content of essential elements in plants is conditional, being affected by the characteristics of the soil and the ability of plants to selectively accumulate some metals (Aksoy et al., 2000). Several plants are used widespread for their many therapeutic and pharmaceutical virtues, especially antioxidant, anti-tumoral, and anti-infectious activities. A big part of the world's population still relies on the benefits of food for the treatment of common illnesses. Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in bio systems through contaminated water, soil and air (Amusan , 2005; Shute and Macfie's , 2003). Therefore, based on environmental persistent nature and cumulative behaviour as well as the probability of potential toxicity effects of heavy metals as a result of consumption of contaminated plant materials, there is need to identify the bioaccumulation potential of edible plants to ensure that levels of these trace elements meet the agreed international requirements. To this end, this study is poised to ascertain the levels of heavy metals accumulation in *citrus reticulata* growing in Urban and rural habitats.

Statement of problem

Due to scarcity or high cost of land which may be suitable for agricultural purposes, it is a general practice, for fruits farmers to cultivate any land which is available to them such as old dumpsites and other contaminated areas into orchards and some farmers who lack access to fertilizers obtain surface soils enrich with organic nutrients from dumpsite to be used as organic manure in their orchards and vegetable farms. Against this background, this study seeks to evaluate the human health risk which could arise from consuming fruits and vegetables grown under such conditions. Shute and Macfie's (2003) work on the cadmium and zinc accumulation in soybeans reinforces the need to monitor concentrations of toxic metals in food crops.

Justification of the study

This study is catalyzed by the strong zeal to verify the heavy metal burden of rural and urban orchards in Uyo Local Government Area of Akwa Ibom State and to ascertain if eating plants from such areas pose any health threat. The study is also relevant since it has been reported that soil contamination may adversely impact human health when agricultural produce grown in such area is consumed.

OBJECTIVES OF THE STUDY

The specific objectives of the study include:

To investigate the heavy metal burden of tangerine orchards soils in uyo Local Government Area.

To investigate the phytoavailability of heavy metals in the fruits of tangerine harvested from these orchards.

To estimate the implication of consuming the fruits using transfer factor analysis.

To estimate the soil-plant heavy metals relationship in the orchards using correlation analysis.

MATERIAL AND METHODS

Samples collection: A total of six orchards were visited (i.e three in both urban and rural areas)**.** In each of these orchards, fruits (3-5g in weight) were collected randomly from healthy citrus plants and soil samples were also collected at a depth of 0-25cm in a ring form just at the base of the plant from which the fruits were plucked. These were used for the heavy metal analyses.

Soil and Plant Sample Digestion:

Samples were ground, mixed, and divided into fine particles that could pass through a 0.5-mm sieve. Soil samples were digested by adding 2 g of soil to 15ml of concentrated nitric acid and perchloric acid at a ratio 1:1, and allowed to stand for 135 min until the mixture became colorless. The samples were filtered and washed with 15 ml of deionized water, and made up the filtrate to 100 ml in a standard flask. Six heavy metals (lead, manganese, Iron, chromium, cadmium, and nickel) were determined in the filtrate at their respective wavelengths using an atomic absorption spectrophotometer (AAS). In all determinations, the triplicate samples agreed very well. The result given is the mean of three estimations and was analyzed statistically using the Student t-test.

RESULTS

Table 1 reveals the mean concentration (in mg/kg) of six (6) heavy metals in the soils of the urban and rural orchards. Iron was the most abundant of these metals assessed in these orchards. The mean concentration of this metal was about 1013.02±7.3 in urban orchards and 143.04±0.1 in rural orchards. Magnesium ranked next with a mean concentration of 54.3±1.4 and 52.9±0.1 in urban and rural orchards respectively. Zinc was found to reach a concentration of 16.4±0.1 and 24.4±0.2 in the urban and rural orchards respectively. The concentration of lead in urban orchards (16.1±0.1) was very close to that of zinc in the same location but in rural orchards the

Table 1. Mean (±S.E) Heavy Metal Properties of Soil of the Two Areas.

	Urban	Rural
Lead(Pb) mg/kg	16.1±0.0	10.8±0.1
Cadmium(Cd) mg/kg	4.4±0.03	3.7±0.2
Zinc(Zn) mg/kg	26.4±0.1	14.4±0.2
Chromium(Cr) mg/kg	13.9±2.6	11.8±0.75
Manganese(Mn)mg/kg	54.3±1.4	52.9±0.1
Iron(Fe) mg/kg	1013.02±7.3	143.04±0.1

Values are Mean of 3 Replicate

Table 2. Mean (±S.E) of Heavy Metals Present in Plant Fruits from the Two Locations.

	Urban	Rural
Lead(Pb) mg/kg	2.6± 0.0	0.8±0.1
Cadmium(Cd) mg/kg	2.4±0.03	1.0±0.2
Zinc(Zn) mg/kg	16.4±0.23	5.4±0.8
Chromium(Cr) mg/kg	8.0±0.6	5.2±0.75
Manganese(Mn)mg/kg	22.7±1.4	18.0±0.1
Iron(Fe) mg/kg	332.5±1.98	352.9±1.4

Values are Mean of 3 Replicate

Table 3. Heavy Metals Transfer Factor in Plant fruits from the Two Sites

	Urban	Rural
Lead(Pb) mg/kg	0.33	2.46
Cadmium(Cd) mg/kg	0.41	0.34
Zinc(Zn) mg/kg	0.57	0.44
Chromium(Cr) mg/kg	0.59	0.27
Manganese(Mn)mg/kg	0.16	0.07
Iron(Fe) mg/kg	0.62	0.32

concentration was slightly elevated with a mean value of 10.8±0.2.Chromium present in these soils ranged between 13.9±2.6 in site 1 up to 15.8±0.75. The least concentrated of heavy metal found in the soils studied was cadmium. It had a mean value of 3.7±0.2 and 4.4±003 in urban and rural orchards respectively.

Table 2 shows the bioconcentration (mg/kg) of six (6) heavy metals in the fruits of *Citrus reticulate*. From the table it can be deduced that Iron was the most concentrated heavy metal in the berries of the species sampled from the two areas. The phytoavailability value of 332±1.98 and 352±3.35 was obtained for Iron in urban and rural orchards respectively. The concentration of manganese was next to Iron. The berries absorbed up to 22.7±0.10 in urban and 18.0±0.1 of manganese in the rural orchards. The least absorbed metal was cadmium having a mean concentration of 2.6±0.1 and 0.85±0.05 in the urban and rural areas respectively.

Transfer factor (TFm) across the urban and rural areas for all heavy metals studied was determined in *Citrus reticulate* over ground (fruits) part and these values are presented in table 3. As it is seen from the data (Table 3) the highest TFm is characteristic of Iron (Fe). The mass-based transfer factor of this element was 0.33 and 2.46 in the species for urban and rural orchards respectively.. Aside from these Fe in the rural orchard, the transfer factor in all cases was less than unity (<1).

DISCUSSION

Heavy Metals in Soil.

From the results, it can be deduced that within the two orchards, the mean concentration of cadmium is comparatively less than that obtained for the other metals and iron is the most sufficient in both soil and harvested fruits. The ascending order of heavy metal content at both dump sites followed the pattern Cd<Pb<Cr<Zn<Mn<Fe. This is bear similarities with the reports of other researchers (Olarinoye and Kolo, 2010; Mbong et al., 2013).

A comparison of the mean concentrations of Fe, Pb, Zn, Mn, Cd and Cr in Table 2 with their corresponding normal range in natural soil: Fe,100-7000mg/kg; Pb,2-200 mg/kg; Zn, 10-300mg/kg; Cd, 2-200; and Cr, 2-100 mg/kg (Vacera *et al.*, 1999), show that these concentrations are within their normal range. The mean concentrations of manganese at both sites were within the natural range in soils (20-100mg/kg) as given by

Ademoroti (1990). Generally, the mean concentrations of the five heavy metals are higher for samples from the urban area than those from rural area with Fe as an exception. The difference in metal concentration between the two areas could simply be attributed to the nature of soil and level of anthropogenic activities going on in these areas. Most human activities such as driving, burning and dumping of electronic / metal waste like empty cans into the orchards contribute to the elevations in metal levels of the urban sites (Mbong et al., 2013).

Heavy metal levels in plants

The mean level of heavy metals in fruits of Citrus reticulate is shown in Table 2. In both orchards, Cd ranged between 1.0 to 2.6 and Pb ranged from 0.80 to 2.6 $mgkg^{-1}$. Cr present in the studied tissues had a range of 5.2 to 8.0 and Zn ranged from 5.40 to 16.40 $mgkg^{-1}$. Mn had range of values from 18.01 to 22.75 $mgkg^{-1}$ while Fe had the greatest concentrations among the metals investigated in the plant. It had values that fluctuated between 332.0 to 352.0 $mgkg^{-1}$. The relative abundances of the heavy metals as detected in the the fruits samples obtained from the orchards followed the sequence: Fe>Mn>Zn>Cr>Pb>Cd. The levels of the metals in the plant were generally lower than those of the soils. It has been reported that high soil pH can stabilize soil toxic elements resulting in decreased leaching effects of the soils toxic elements (Li *et al*., 2005). This may explain the low absorbability of the elements from the soil solution and translocation into plant tissues.

The increased heavy metals availability index of the urban orchard plants could be linked to the indiscriminate dumping of refuse into these orchards and the use of humus-rich dumpsite soils as fertilizer in this area. In confirming this, studies have shown that crops harvested from soils of the refuse dump sites presented higher levels of the metals when compared to the those crops from the control sites (Mbong, *et. al*. 2013). This may be interpreted that if the level of these metals in soils is significantly increased, the plants have the potential of showing increased uptake of the metals. This is also supported by studies that plants grown in soils possessing enhanced metal concentrations have increased heavy metal ion content (Alloway and Ayres, 1997; Amusan *et al.,* 2005). Also, levels of heavy metals in plants as revealed in this study; are similar with earlier reports on plants growing in roadside soils in Kaduna metropolis (Okunola, *et al*., 2008; Aksoy *et al.,* 2000). This confirms that there is a direct relationship existing between anthropogenic activities like driving in the urban area and phyto availability of heavy metals in this species due to the proximity of these orchards to traffic routes. Correlation analysis between heavy metals in plants and soil as shown in Table 4 strong and positive correlation between the concentration of heavy metals in plants tissues and soil, confirming this relationship. It can therefore be inferred that with an increase in the amount of metals in soil, the uptake of metals by plants also increases. According to Awofolu, 2005 the positive relationships between plants and soil content of metals might be a cause of metal toxicities to both plants and animals through their entry into food chain.

Transfer Factor (TF_m)

The Transfer factor (TF_m) is a competent technique developed to assess the level of the metal in the plant as a fraction of the soils total. Previous studies have indicated that the uptake of metals by plants differs from one metal to another, from one plant species to another and from one dumpsite to the other (Amusan *et al.,* 2005; Agyarko *et al*., 2010). The results from this study as shown in Table 5 and 6 indicated that the uptake of each metal differs from one dump site to another and from one plant part to another. This variation might be explained in terms of the available salts present in the soil which differ from one dumpsite to the other. The ranges of BCF for *Ipomea batatas and Laportea ovalifolia* leaves and roots in both dump sites ranged differently. The range for each metal is as follows: Pb: 0.10 to 0.19, Cr: 0.30 to 0.64, Zn: 0.24 to 1.71, Cd: 0.19 to 0.73, Mn: 0.27 to 0.71 and Fe: 0.24 to 2.46 respectively.

The mean BCF value for Zn in *I batatas* (leaves) harvested from Site 1 was unity, which indicated that the concentration of the metal in the plant was equal to that of the soil while the mean BCF value for Fe in *I batatas* and *L. ovalifolia* (leaves) harvested from Site 2 was greater than unity indicating a higher concentration of the metal in the plants than in the soil. The results also showed that the BCF value for Zn in *I. batatas* (roots) at site 1was greater than unity. This indicated that plant uptake of this metal at the sites were not restricted by pH or other parameters. In terms of root absorption, Fe also depicted BCF greater than unity in *I batatas* and *L. ovalifolia* at site 2. Amusan *et al* (2005) reported that other factors apart from total soil metal concentration could influence the bioaccumulation factor (soil plant transfer ratios). Chambers and Sidle (1991) found that metal levels in plants highly vary when related to soil metal levels and according to Fleming and Parle (1977), the uptake of heavy metals varies widely depending on the plant species being studied. They also found out that metal uptake was controlled by such variables like pH, organic matter content and soil type. Generally most of the heavy metals are less available to plants under alkaline conditions than under acid conditions (Hess and Schmid, 2002). The high level of these metals in the plant at these sites might be due to direct deposition and foliar absorption more than the translocation from roots to the upper part of the plant.

REFERENCES

Abdallah SA, Uzairu A, Kagbu JA, Okunola OJ (2012). Assessment of heavy metals bioaccumulation by *Eleusine indica* from refuse dumpsites in Kaduna Metropolis, Nigeria J. Environ. Chem. Ecotoxicol. 4(9): 153-160.

Adefemi OS, Awokunmi EE (2009). The impact of municipal solid waste disposal in Ado Ekiti metropolis, Ekiti State, Nigeria. Afr. J. Environ. Sci. Tech. 3(8): 186-189.

Ademoroti CMA (1990). Bio-accumulation of Heavy Metal in some Mangrove Fauna and Flora. In: Environ. Chem. Toxicol. Consultancy, Benin. Pp. 180–182.

Ademoroti CMA (1996). Standard methods of chemical analysis, March Print and consultancy, Benin, Nigeria.

Albores AF, Perez-Cid B, Gomes EF, Lopez EF (2000). Comparison Between Sequential Extraction Procedures and Single Extraction Procedures and for metal Partitioning in sewage sludge samples. Analyst. 125: 1353-1357.

Alloway BJ, Ayres DC (1997). Chemical Principles of Environmental Pollution. 2nd edu. Black Academic and Professional Publ. Pp. 190-217.

Aluko OO, Sridha MKC, Oluwande PA (2003). Characterization of leachates from a municipal solid waste landfill site in Ibadan, Nigeria. J. Environ. Health Res. 2: 1.

Amusan AA, Ige DV, Olawale R (2005). Characteristics of Soil and Crop uptake of metals in municipal waste dumpsites in Nigeria. J. Hum. Ecol. kamla Rja. 1(2): 167-171.

Amusan AA, Ige DV, Olawale R (2005). Characteristics of soil and crops uptake of metal in municipal waste dumpsites in Nigeria. J. Hum. Ecol. 17: 167-171.

Andráš P, Lichý A, Rusková J, Matúšková L (2010). Heavy Metal Contamination of the Landscape at the Ľubietová Deposit (Slovakia). Int. J. Civil and Environ. Engineer. 2(2): 334-355.

Ataabadi M, Hoodaji M, Najafi P (2010). HeavyMetals Biomonitoring by Plants Grown in an Industrial Area of Isfahan' Mobarakeh Steel Company. J. Environ. Studies. Pp. 35-52.

Awofolu OR (2005). A survey of trace metals in vegetation, soil and lower animals along some selected major roads in metropolitan city of Lagos. Environ. Monit. Assess. 105: 431-447.

Baldini M, Stacdhini P, Cubadele F, Miniero R, Parodi P, Facelli P (2000). Cadmium in Organs and Tissues of Horses, Slaughtered in Italy. Food Addit. Contam. 17(8): 676-687.

Bamgbose O, Arowolo TOA, Odukoya O (2000). Earthworms as bioindicators of metal pollution in dumpsites of Abeokuta. *Nigeria.* Rev. Biol. Trop. 48: 56-62.

Bishop PL (2000). Pollution Prevention: Fundamentals and Practice. McGraw-Hill, Companies Inc.,U.S.A. Pp. 67-89.

Bukar LI, Hati SS, Dimari GA, Waziri M (2012). Applicability of Linear Regression Model for the Estimation of Mobility Factor of Heavy Metal in Contaminated Soil against Native Concentrations Advances in Analytical Chem. 2(2): 1-5.

Buszewski B, Jastrzębska A, Kowalkowski T, Górna-Binkul A (2000). Monitoring of Selected Heavy Metals Uptake by Plants and Soils in the Area of Toruń, Poland.

Campbell DJV (1993). Environmental Management of Landfill Sites. J.I.W.E.M. 7(2): 170-173.

Carlson CW (1976). Land application of waste materials, Soil Conserv. Soc. Am. Ankeny, IOWA. Pp. 3-7.

Chambers J, Sidle P (1991). Fate of heavy metals in an abandoned lead-zinc tailings pond: 1, Vegetation. J. Environ. Qual. 20: 745-758.

Federal Environmental Protection Agency (1995). Corporate profile. Metro prints Ltd, Port Harcourt.

Fleming G, Parle P (1977). Heavy metals in soils, herbage and vegetables from an industrialized area west of Dublin city. Irish. J. Agric. 16: 35-48.

Gupta SK, Chen KY (1975). Partitioning of trace metals in selective chemical fractions of nearshore sediments. Environ. Lett. 10: 129-158.

Kamarudzaman AN, Zakaria MAH, Aziz RA, Ab-Jalil MF (2011). Study the Accumulation of Nutrients and Heavy Metals in the Plant Tissues of *Limnocharis flava* Planted in Both Vertical and Horizontal Subsurface Flow Constructed Wetland. International Conference on Environment and Industrial Innovation IPCBEE vol.12 IACSIT Press, Singapore.

Kozanecka T, Chojnicki J, Kwasowski W (2002). Content of Heavy Metals in Plant from Pollution-Free Regions. Polish J. Environ. Studies. 4: 395-399.

Manios T, Stentiford EI, Millner PA (2003). The effect of heavy metals accumulation on the chlorophyll concentration of Typha latifolia plants, growing in a substrate containing sewage sludge compost and watered with metaliferus water. Ecol. Engineer. 20: 65-74.

Mench M, Didier VL, Loffler M, Gomez A, Masson P (1994). A mimicked *in-situ* remediation study of metal-contaminated soils with emphasis on cadmium and lead. J. Environ. Qual. 23: 58-63.

Narayanan P (2009). Environmental Pollution. Principles, Analysis and Control. 2nd ed.New Delhi. P21-34

Odukoya OO, Bamgbose O, Arowolo TA (2000). J. Pure and Appl. Sci. 7: 467-472.

Ojeshina OA (1999). Sanitary and Hazardous Waste: Landfill as a Waste Disposal Strategy for Nigerian settlement. A paper presented at a one day workshop as part of the activities to mark FEPA's 10th year anniversary, Nigeria.

Ojeshiria OA (1999). Sanitary and hazardous waste: Landfill as a waste Disposal stage for Nigeriasettlement. A paper presented at FEPA 10th year anniversary, in Nigeria. Retrieved from:http://www.iss.co.za/af/profiles/nigeria/population.html.

Okoronkwo NE, Igwe JC, Onwuchekwe EC (2005). Risk and health implication of polluted soils for crops production. Afr. J. Biotechnol. 4(13): 1521-1524.

Okoronkwo NE, Odemelam SA, Ano OA (2006). Levels of toxic elements in soils of abandoned waste dumpsite. Afr. J. Biotechnol. 9(15): 561-574.

Okunola OJ, Uzairu A, Ndukwe GI, Adewusi SG (2008). Assessment of Cd and Zn in roadside surface soils and vegetations along some roads of Kaduna Metropolis, Nigeria. Res. J. Environ. Sci. 2(4): 266-274.

Predrag I, Slobodanka P, Sanja T (2003). The content of heavy metals in tissue of C*eratophyllum demersum* L. from Danube-Tisza-Danube canal in Banat region of Vojvodina (Serbia and Montenegro) Act a Bot. Hung. 30(1-2): 173-185.

Radanovi D, Anti-mladenovi S, Jakovljevi M, Kresovi M (2006). Content of heavy metals in *Gentiana lute a* L. roots and galenic Forms J. Serb. Chem. Soc. *72* (2): 133–138.

Smith CJ, Hopmans P, Cook FJ (1996). Accumulation of Cr, Pb, Cu, Ni, Zn and Cd in soil following irrigation with untreated urban effluents in Australia. Environ. Pollut. 94(3): 317-323.

Uba S, Uzairu A, Harrison GFS, Balarabe ML, Okunola OJ (2008). Assessment of heavy metals bioavailability in dumpsites of Zaria Metropolis, Nigeria. Afr. J. Biotechnol. 7(2): 122-130.

Uboh FE, Akpanabiatu MI, Edet EE, Okon IE (2011). Distribution of heavy metals in fluted pumpkin (*Telfairia occidentalis*) leaves planted at different distances away from the traffic congested highways. Int. J. Advanced Biotechnol. Res. 2(2): 250-256.

Udo EJ, Ogunwale JA (1978). Laboratory manual for the analysis of soils, plants and water samples. Department of Agronomy University of Ibadan. Pp. 45.

Udossien DB (2003). Principles and Theories of Environmental Pollution. (2003). Rostian Press. Port Harcourt.

United States Environmental Protection Agency (USEPA) (1986). Quality Criteria for Water. United States Environmental Protection Agency. Office of Water Regulations and Standards. Washington D.C. 20460.

Vwioko DE, Anoliefo GO, Fashemi SD (2006). Metal Concentration in Plant Tissues of *Ricinus communis* L. (Castor Oil) Grown In Soil Contaminated With Spent Lubricating Oil. J. Appl. Sci. Environ. Mgt. 10(3): 127–134.

Walkley A, Black IA (1934). An Examination of the Detjare Method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid titration. Soil Sci. 37: 29-36.

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