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Elemental contents of some medicinal plants using energy dispersive x-ray fluorescence (EDXRF)

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The presence of some elements in ten plants with anti-microbial potency was analysed using x-ray fluorescence technique. The results showed there were nineteen elements in these plants. They all contain Pb, a toxic heavy metal, except one that contains As. K, S, Ca, Fe, Zn, Cu, Co, Ni, Mn and Se elements were identified and their anti-microbial properties were discussed.

Key words: Energy dispersive x-ray fluorescence, anti-microbial plants, heavy metals, Côte d'Ivoire.

INTRODUCTION

In Africa, microbial diseases like tetanus, whooping cough, diarrhea, cholera and AIDS affect both rural and urban dwellers. This can be attributed to several factors such as high cost of modern medication and inability of rural population to access modern medicines as they are sold in hospitals that are far away from them. In Côte d'Ivoire, just like most Third world countries, rural people use medicinal plants to treat diseases (Kamanzi et al., 2002). Medicinal plants are the main sources of traditional medicine for the rural population and are used for their therapeutic properties because they are known to have many essential and nutritional elements (Djama et al., 2011).

A study was done in Côte d'Ivoire mainly to identify plants used for pharmacological preparations and their properties frequently used in traditional medicine; the elemental composition of the plants in relation to their use was also studied. The study focused on the plants used in the treatment of microbial diseases which the population of Côte d'Ivoire is exposed to. Plants were selected for their therapeutic uses for various illnesses (Aké-Assi, 2001). The aim of the present study is to investigate the elemental contents in plants and review their therapeutic properties. The work also aims to evaluate the level of toxic elements present in medicinal plant samples (Djama et al., 2012). Ten medicinal plants were studied to determine their elemental contents. These are: *Abrus precatorius* (Subhan and Jubilee, 2006), *Cassia alata* (Khan et al., 2001), *Justicia secunda* (John et al., 2006), *Manotes longiflora* (Kablan et al., 2008), *Ocimuma mericamum* (Clarkson et al., 2004), *Ocimum gratissimum* (Pousset, 2004), *Phyllanthus amarus* (Hanumanthachar and Milind, 2007), *Psidium guajava* (Pousset, 2004), *Solenoste monmonostachyus* (Adjanohoun and Aké-Assi, 1979) and *Blighia unijugata* (Oderinde et al., 2009).

MATERIALS AND METHODS

The plants were collected from July 2007 to July 2008 at AGBAN-Bingerville, a village in Côte d'Ivoire (Figure 1). Previous studies show that these plants were used in traditional medicine for their

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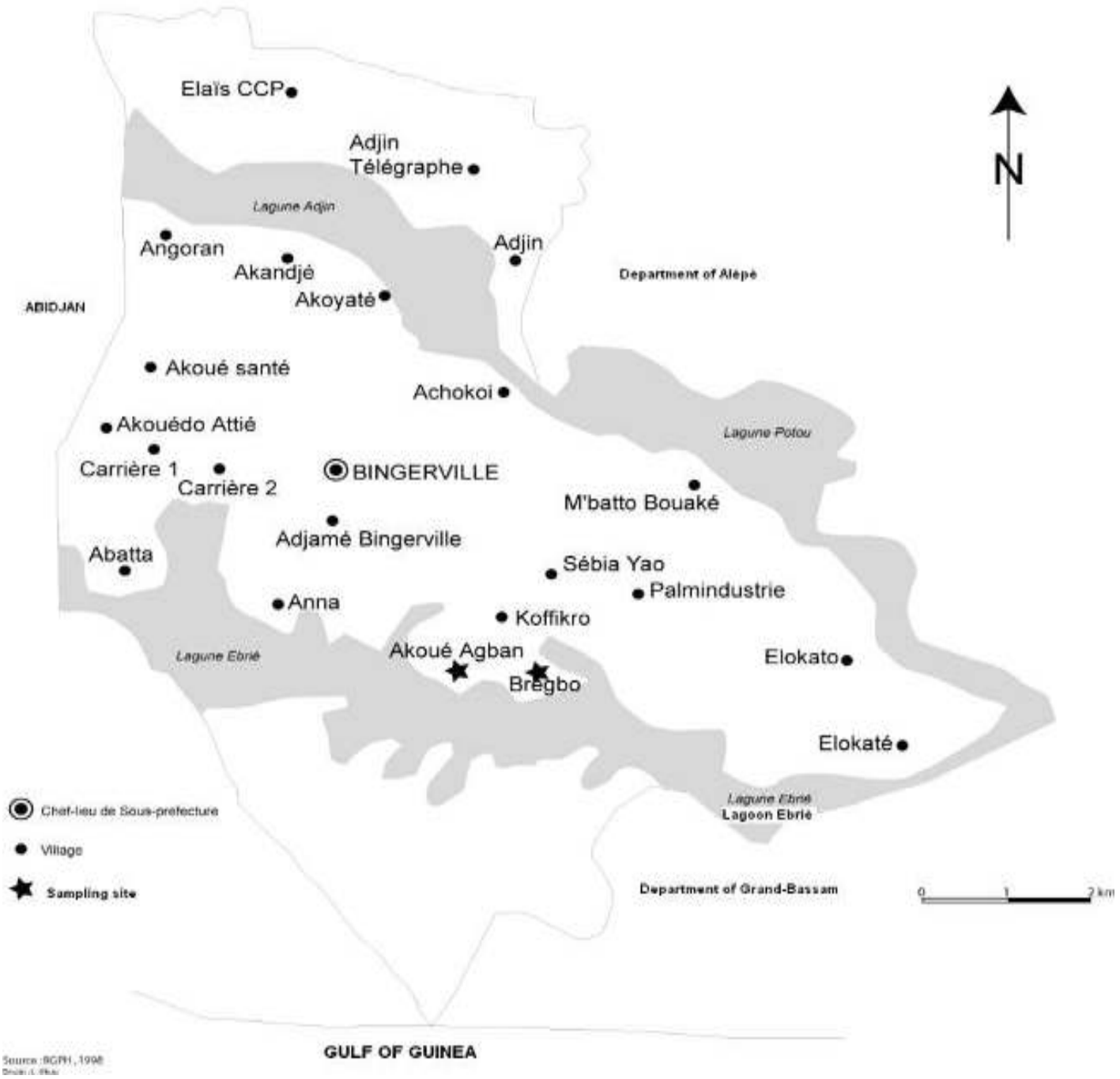

Figure 1. Map showing the sampling sites.

antimicrobial properties. The parts of the plants used were leaves, and stems barks. Ten plants (Table 1) were used for the study. They were cleaned with distilled water to avoid contamination, and dried at ambient laboratory temperatures in the range of 20 to 30°C. They were grinded into fine powder to make pellets. Irradiation was done using an energy dispersive X-Ray fluorescence spectrometer. Tube excited X-Ray photons from a Mo-anode in a Mo secondary target excitation were used. The tube was operated at 45 kV/5 mA. A 30 mm^2 active area Si (Li) detector with an energy resolution (FWHM) of 165 eV at 5.9 keVMn Kα was used to detect the characteristics of the photons; it was placed on the sample surface area at 45°. An ortec maestro Multichannel analyser programme was employed for the data collection (peak collection). About 300 mg of each sample was pelletized using a SPECAC material with a pressure of 2 tons/cm^2 .Three irradiations were done for each pellet: The intermediate thick pellet, multi-element target and Pellet + Target for a spectrum collection life time of 1500 s. IAEA Linear least squares fitting of the AXIL software programme was used for the spectrum deconvolution. The emission-transmission method in QXAS package (IAEA, 2005) was used to convert

Table 1. Some antimicrobial medicinal plants used in Côte d'Ivoire.

Scientific name	Family name	Part used	Code
Abrus precatorius	Fabaceace	Leaves	PT12
Blighia unijugata	Sapindaceae	Stems bark	PT27
Cassia alata	Caesalpiniaceae	Leaves	PT01
Justicia secunda	Acanthaceae	Leaves	PT07
Manotes longiflora	Connaraceae	Leaves	PT02
Ocimum americamum	Lamiaceae	Leaves	PT26
Ocimum gratissimum	Lamiaceae	Leaves	PT18
Phyllanthus amarus	Euphorbiaceae	Leaves	PT33
Psidium guajava	Myrtaceae	Leaves	PT06
Solenostemon monostachyus	Lamiaceae	Leaves	PT25

spectrum peak areas to concentrations.

RESULTS AND DISCUSSION

The results of the elemental analysis showed that there were nineteen elements. The major elements detected were potassium, sodium and calcium. The trace elements were vanadium, chromium, manganese, iron, cobalt, nickel, copper, zinc, arsenic, selenium, bromine, rubidium and strontium at various concentrations.

These anti-microbial plants contain molecules that behave like antibiotics (Okpekon, 2006). The study was done to determine the elements in these plants that are essential for the treatment of microbial diseases. The essesntial ones K, S, Ca, Fe, Cu, Zn, Ni, Co, Mn and Se. The results of the analysis are seen in Table 1.

Trace elements

Iron (Fe) is used to fight anemic disorders (Nazanin et al., 2014). The Fe content in the various medicinal plants analysed varies between 100 mg/kg in PT01_Leaf to a 1094,8 mg/kg in PT25_Leaf (Table 2). Hence, *S. monostachyus* has the potency to treat illnesses such as malaria and helminthiasis disorders. The Fe concentration levels in the studied plant parts renders them good enough for used in the treatment of bacteria diseases.

The Copper (Co) contents in the plant parts studied varied from 2.2 mg/kg in PT06_leaves to a maximum of 11 mg/kg in PT25_leaves. The adult human body contains approximately 1 mg of cobalt, 85% of which is in the form of Vitamin B_{12} (Lison, 2007). Cobalt constitutes a small part of Vitamin B12. The organic form of cobalt is a necessary component of Vitamin B12 and plays a very important role in forming amino acids. This element is essential for organisms to function well (Katarzyna et al., 2015). PT25_leaves having higher Co and Fe contents suggest they are used in medicinal preparations to treat microbial diseases and anaemia.

Co has anti-inflammatory properties (Lewis, 1984; Whitehouse, 1976). Co concentrations ranged from 2.7 mg/kg in *C. alata* leaves to 11.6 mg/kg in *O. gratissimum* leaves. It is used for treating tetanus. Leaves of *C. alata* and *O. gratissimum* can be recommended for curing tetanus.

Nickel is also a micronutrient essential for proper functioning of the human body. This metal facilitates the transition to the human body through respiratory tract, skin and digestive system (Zdrojewicz et al., 2016). All plants investigated here contain nickel but it is prominent in leaves of *S. monostachyus* (3.8 mg/kg) and *M. longiflora* (8.4 mg/kg). These two plants can be used more for anaemia disorders than the others. Ni can be toxic to high levels concentrations but the maximum value (8.4 mg/kg) is inferior to UL and RDA values.

The conclusions of the works of Nazanin et al. (2013) confirmed that zinc deficiency caused an increase in the frequency of infections. The samples analysed containing zinc are *phyllanthus amarus* (37.8 mg/kg), *J. secunda* (35.4 mg/kg), *C. alata*(13.2 mg/kg), *O. gratissimum* (38.4 mg/kg), *A. precatorius* (27.7 mg/kg), *O. americamum* (40.2 mg/kg), B. *unijugata* (4.9 mg/kg), *M. longiflora (*6.0 mg/kg), *S. monostachyus (150* mg/kg). The appreciable high concentration of Zn in PT25_Leaves, PT40_Leaves, PT18_Leaves, P33_Leaves, PT07_Leaves and PT06_Leaves suggests its possible use for the improvement of the immune system and treatment of microbial infections.

The deficiency of Mn element could cause skin damage, anaemia and hypercholesterolemia. It helps in eliminating fatigue and together with Fe, it can be used to treat anaemia (Djama et al., 2011). Mn concentrations varied from 5.6 mg/kg in stem barks of *B. unijugata* to 205.6 mg/kg in leaves of *J. secunda.* Appreciable high concentrations are found in leaves of *A. precatorius* (49.9 mg/kg), *S. monostachyus (*57.6 mg/kg), *O. americamum* (29.7 mg/kg) and *P. amarus (*64,6 mg/kg). These plants can be used for medicinal preparations to supplement Mn for various functions of the body **(**Djama et al., 2011).

Selenium (Se) is a well-known antioxidant (Navarro-

Table 2. The various plant parts studied and their elemental contents in mg/kg (ppm).

Element	PT12_Leaf	PT27_stem_branks	PT01_Leaf	PT07_Leaf	PT02_Leaf	PT26_Leaf	PT18_Leaf	PT33_Leaf	PT06_Leaf	PT25_Leaf	RDA (per day) adults. mg[19]	UL(per day) adults[19]
S	-	1023.5±713.7	-	-		-	-	1779.8±120.3	-	-	-	-
Cl	-	-	-	-		-	-	-	-	780.7±691.2	-	
K	4102.7±2437.9	3140.1±1089.1	2585.5±179.4	687.5±122.9	865.8±137.9	5247.6±1021.6	8781.3±6561.1	4068.3±2474.6	4426.1±255.7	10000.0±4000.0	800-1200 mg	-
Ca	3879.7±2302.7	14500.0±4900.0	3160.5±193.6	1899.3±124.6	4289.7±555.8	4750±885.1	7262.8±5422.1	3181.2±1931.7	2372.3±139.3	10600.0±4300.0	-	-
Ti	42.3±26.6	-		-	-		-	-	11.4±10,2	136.8±61.8	<1,8 mg	1,8mg
V	-		-	-	-	-	-	-	-	17.9±13.1	-	-
Cr	11.1±7.2	-	-	-	3.2±2.7	-	-	6.2±5.2	-	13.0±9.8	1.0-5.0 mg	11mg
Mn	49.9±27.8	9.1±4.1	7.0±2.1	5.6±3.2	205.6±23.8	29.7±9.2	9.0±7.6	64.6±36.7	7.9±2.4	57.6±23.9	8-18 mg	45mg
Fe	364.4±192.4	119.6±38.8	100±5.9	191.4±11.6	108.6±12.3	145±26.4	104.5±76.9	244.3±131.6	119.4±6,6	1094.8±439.3	-	-
Co	3.1±2.6	-	-	2.7±2.2	1.4±1.2	3.1±2.1	-	3.8±2.7	2.2±1.4	11.6±6.3	0.13-0.4 mg	1.000 µg
Ni	1.9±1.4	2.3±1.1	2.4±0.7	1.9±1.5	8.4±1.2	1.4±1.3	3.0±2.4	2.9±1.7	2.5±0.8	3.8±2.0	0.9 mg	10mg
Cu	6.6±3.0	5.3±1.7	2.7±0.7	6.1±0.9	4.6±0.8	10.6±2.0	11.6±8.0	7±3.1	7.6±0.8	10.8±4.3	11 mg	40mg
Zn	27.7±1..6	4.9±1.5	13.2±1,0	35.4±2.0	6±0.8	40.2±6.0	38.4±25.0	37.8±14.6	21±1.2	150.3±54.7	-	-
As	-	-	-	-	-	2.1±0.8	-	-	-	-	55 µg	400µg
Se	0.4±0.3		1.4±0.3	-	-	-	0.4±0.3	-	-	-	1.5-2.5 mg	-
Br	7.3±1.6	10.7±1.7	6.2±0.4	17.9±1.0	5.1±0.4	3.2±0.6	14.0±6.0	11.7±2.6	11.6±0.7	18.5±4.6	-	-
Rb	32.4±5.7	8.9±1.2	20.2±1.0	18.8±1.0	31.2±1.7	20.6±1.7	27.9±9.5	16.8±2.9	23.9±1.1	29.6±6	-	-
Sr	38.1±6.0	73.1±8.2	22.9±1.1	62±2.8	42±2.2	17.8±1.3	35.9±11.0	24.0±3.7	14.7±0.8	40.8±7.5	-	-
Pb	1.7±0.9	1.1±0.8	1.6±0.7	3.8±1.2	2.7±0.8	1.8±1.1	1.3±1.1	1.4±0.9	2.4±1.1	4.9±1.8		

UL: Tolerable upper intake levels; RDA: Recommended Dietary Allowance; Concentrations of elements are in mg/kg (ppm); Stem b.: Stem barks.

Alarconet al., 2008). This element is needed for the proper functioning of the immune system, and is a key nutrient in counteracting the development of virulence and inhibiting HIV progression to AIDS (Rayman, 2000). Only three plants contain Se: PT12_Leaf (0.4 mg/kg), PT01_leaf (1.4mg/kg) and PT18_Leaf (0.4 mg/kg). It is suggested for use in the treatment of AIDS infection.

Essential elements

Peter and Kowey (2002)'s study shows that potassium is very important in regulating water balance and acid-base balance in the blood and tissues. It is essential in the transmission of electrical impulses in the heart. All plants contain K. The minimum concentration is 68.5 mg/kg and the maximum is 10.000 mg/kg. The higher K content in PT25_leaves suggests its uses in medicinal preparation for good heart impulsions and can help to treat hypokalaemia.

Calcium element in the human organism is essential. It regulates muscle contraction, oocyte activation, and building of strong bones and teeth (Piste et al., 2013).

The works of Ralf Mueller showed that sulfur is necessary in clinical applications, for treating skin disease. Two of the analyzed plants contain S: *P. amarus (*1779.8 mg/kg) and *B. unijugata* (1023.5 mg/kg).This element causes irritant reactions (Ralf, 2008).

Calcium concentrations varied from 1899.3 mg/kg in *J. secunda* leaves to 14.500 mg/kg in stem barks of *B. unijugata*. Appreciably high concentrations of the element was found in *P. amarus* (3181.2 mg/kg), *C. alata* (3140.1 mg/kg),

O. gratissimum (4750 mg/kg), *A. precatorius* (3879.7 mg/kg), *O. americamum* (7262.8 mg/kg), *B. unijugata* (14.000 mg/kg), *M. longiflora* (4289.7 mg/kg) and *S. monostachyus (*10.600 mg/kg). These plants are good for regulating the heart during treatment for bacterial infections.

Heavy metals

Sudies by Yedjou and Tchounwou (2008) and Yedjou et al. *(*2006) revealed that Lead (Pb) is a toxic element. All the analyzed plants contain Pb: The minimum concentration is 1.1 mg/kg in PT12_leaf while the maximum is 4.9 mg/kg in PT25_leaf.

It is only *O. americanum* that contains arsenic (2.1 mg/kg) that is toxic, especially in its inorganic form (WHO, 2018).These different plants' parts should be used with recommendation and prudence.

Conclusion

This work lists ten plants used by traditional healers in Côte d'Ivoire to treat illnesses resulting from microbial infections. The data obtained in the present work revealed the curative potency of the analyzed plants; it will also be necessary to determine the dosage to be administered to patients considering the elemental contents and their concentrations in these plants. This study sought to identify the presence of elements in these plants that can improve patients' state of health from their metabolic properties. From the analysis of the results obtained, the concentrations of the essential elements in the plants contributed effectively to the healing of bacterial diseases. These plants are indicated in the treatment of microbial diseases as pointed out previously., However, some are more effective than others. The leaves of *S. monostachyus* can be recommended for parasitic infections, leaves *of A. precatorius*, *C. alata and O. gratissimum* may be recommended for patients with bacterial infections and AIDS as they contain potassium, calcium, iron, nickel, copper, manganese, zinc and selenium. These plants can correct the side effects of diseases such as anaemia, weakening of the immune system and general fatigue. In addition, the leaves of *J. secunda*, the stems of *B. unijugata* and the leaves of *M. longiflora* are effective for curing anaemia and strengthening of the immune system. All parts of the plants should be used with moderation and prudence.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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