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Original Article

Metals and Metal Ions in Some Plants Used for Wound Healing in Zimbabwe

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ABSTRACT
Plant roots were dried in the shade, chopped and ground to powder, and the metallic species freed from the plant by wet oxidation. The concentrations of selected metal ions were determined by atomic absorption spectroscopy, revealing a wide range of metallic elements in the roots. The importance of these elements in the different human normal metabolic processes and the different human disorders is discussed. The availability of some of these metallic elements in the plants might justify the use of the plants by traditional healers in wound healing processes. However, the availability of some known poisonous elements in the plants in question might raise problems in relation to undesirable effects of the plants in their use for medicinal purposes.
Key words: *Asparagus, inorganic ions, heavy metals, medicinal use.*

INTRODUCTION

The demand for herbal drugs is increasing due to the growing recognition that these are natural products having no or little side effects and can easily be available at affordable prices and sometimes they are the only source of health care available to poor people particularly in the third world countries [1]. African traditional medical practitioners have over the years been treating various wounds with herbal remedies [2], using the bark, leaves, roots, twigs, and whole plant as decoctions [2][3][4]. Use of decoctions to treat wounds would imply use of water extracts of the plants, which would include water soluble organic and inorganic compounds. Considerable importance has been attached to the availability of organic compounds found in the plants to explain the efficacies of the medications [2][5]. However, plant ashes are widely used by traditional health practitioners to treat different kinds of wounds [4]. Ground powder is burnt in a clay pot using wood fire and the ash is applied directly on to the fresh wound or moistened and used to plaster an older wound. Comparatively less effort appears to have been exerted in connection with the effects of the metals and metallic ions on the overall health of the patient. Literature reports on the desirable effects of inorganic constituents of traditional medicinal plants, but some of the reports on these constituents are a cause for concern. Many metal ions are reported as necessary for the activity of other drugs [6][7]. In recent years scientific interest in the use of metal hyper-accumulating plants in phytoremediation has increased notwithstanding that metal-accumulating plants have a broader potential as a way to improve peoples' diets or even to create foods that fight cancer [8].

Metals as essential microconstituents

Many metals are essential micronutrients that play a crucial role in certain enzymes used for proper functioning of the body. The lack of proper micronutrients causes health problems in many undeveloped nations, particularly in children and pregnant women [8].

Metalloenzymes

Metalloenzmes have an important role in repair and regenerative processes in skin wounds. Demands for different enzymes vary according to the phase in the healing cascade and constituent events [9]. Physiological and toxicological changes have been noticed in the skin as a result of action and interaction of metal ions. Zinc, calcium, copper, magnesium, and iron have specific roles in skin morphogenesis and function, the balance of the trace metals being critical for normal skin and repair mechanisms following injury. Some ions can impair this balance and cause pathological changes [10].

Aluminium, antimony, cadmium, lead, and nickel

Excessive levels of some of elements such as aluminium, cadmium, and lead can have unbalancing effect on trace element balance in the body cells [11] and excessive amounts of the trace elements will also lead to problems. Cadmium is known to cause hypertension, cancer, and immune disorders. It is very toxic on its own and also increases toxicity of other agents [11]. Some metals have a major role in tissue repair systems as cofactors in metalloenzyme systems and as structural components [12]. Aluminium, cadmium, and antimony ions induce release of granule associated N-acetyl-β-d-hexosaminidase, and aluminium and nickel ions enhance antigen-mediated release. Some metal and transition metal ions also induce significant secretions of interleukin(II)-4-and increase antigen-mediated IL-4 secretion in mast cells [13].

Manganese

Manganese is essential as a trace metal supplied to the brain via both the blood-brain and the blood-celebrospinal fluid barriers. Dietary manganese deficiency, which may enhance susceptibility to epileptic functions, is reported to affect manganese homeostasis in the brain, probably followed by alteration of neural activity. Abnormal concentrations of manganese in the brain, especially in the basal ganglia, are associated with neurological disorders similar to Pakinson's disease [14]. Manganese toxicity has been reported through occupational and dietary overexposure and is evidenced primarily in the central nervous system, although lung, cardiac, liver, reproductive and foetal toxicity have been noted. Repeated administration of manganese, or compounds that readily release manganese, may increase the risk of manganese-induced toxicity [15]. Manganese intake can vary greatly with food choices, water composition, and supplementary use. Many of the symptoms of manganese deficiency (growth retardation, changes in circulating cholesterol and glucose levels, reproductive failure) and manganese toxicity (growth depression, anemia) are non-specific [16]. The body is protected against manganese toxicity primarily by low absorption and /or rapid pre-systemic elimination of manganese by the liver [17]. Manganese displays a somewhat unique behaviour with regard to its toxicity. It is relatively non-toxic to the adult organism except to the brain where it causes Parkinson-like symptoms when inhaled even at moderate amounts over longer periods of time. Manganese deficiency can also affect fertility and be teratogenic [18].

Heavy metals

It has been observed that boiling the medicinal plant in water leads to the extraction of higher amounts of the heavy metals from the plant than immersing the plant in the hot water [19]. Heavy metals cause a high risk because they may accumulate in vital organs. Children are most susceptible to the toxic effects of heavy metal poisoning. Arsenic poisoning can affect the liver, bone marrow, cardiovascular system & central nervous system, causing nausea, abdominal pain, vomiting, muscle cramps, heart abnormalities, liver damage, anaemia and reduced mortar nerve functions. Lead poisoning can affect the kidneys, liver, heart and central nervous system, causing weight loss, insomnia, dizziness, swelling of the brain and paralysis [20].

Chromium

Chromium is a mineral required in small quantities by the body. It enables insulin to function normally and helps the body process (metabolize) carbohydrates and fats. As a dietary supplement, chromium picolinate is used to promote weight loss, build muscle, reduce body fat, and enhance the functions of insulin. But a number of disorders in humans, such as damage to the liver, kidneys, respiratory & nerve tissue are occurring because of chromium [1].

The concentrations of the various elements vary depending on plant species and availability in the soil. Narendhirakannan, et al. [21] report that copper, nickel, zinc, potassium, and sodium are found in the trace amounts in some medicinal plants, whereas levels of iron, chromium, and vanadium have been found to be marginal. The report is contrary to our observations (unreported work). In the same report, Narendhirakannan, et al., report that some metals have remained medicinally useful regardless of overwhelming evidence of their toxicity.

Lithium

Medicinal interest in lithium began in the mid 1800s and led to the belief that lithium was useful in the treatment of gout. However it later proved to be ineffective [22], although it was noted to be highly effective in the treatment of psychiatric disorders in the late nineteenth century but its toxicity limited its acceptance at that point. It has, however, been used for treatment of patients with mood disorders, depression, manic depression and melancholia. Alternative psychiatric agents have been adopted for the treatment of these disorders due to the growing recognition of lithium nephrotoxicity. Although lithium is chemically closely related to sodium and potassium, it has no role in human physiology though it can be substitute for sodium in many sodium channels. The most common complication of chronic lithium therapy is nephrogenic diabetes insipidus and lithium has been cited as the most common cause of this disease [23]. Patients with urine-concentrating defects resulting from lithium treatment usually take weeks to months to recover following discontinuation of the drug. In rare cases the problem persists. Lithium remains important to us because it has been observed in some of our medicinal plants (unpublished work).

In view of such phenomena as the (1) sister-chromatid exchanges after exposure to metal-containing emissions [24], (2) effects of metal ions on lipid peroxidation [25], (3) metal ions modulation of gene expression and accummulation [26], (4) the effect of cell monolayer density on the cytotoxicity of metal ions [27], and the other evidence of the effects of metals on health, there might be merit in studying the possible effects of metals and metal ions found in plants which are used for medicinal purposes. Besides, the complexity of the roles of metals on human health renders the documentation of metals in traditional medications very important.

Objective

The objective of this study is to document the metals and metal ions in the ashes of the root of *Asparagus laricinus* and *Asparagus africanus*, the bark of *Dichrostatchys cinerea* and the bark of *Xeroderis stuhlamannii*, then attempt to explain their possible medicinal roles in wound healing as used by traditional healers in Zimbabwe.

Rationale

When traditional healers burn plant parts and use the resultant ashes to cure patients they are effectively prescribing inorganic oxides to the patients. The nature of the oxides need to be documented so as to create a database of inorganic materials from plants of medicinal value and possibly highlight the possible effects of these inorganic materials on the patient.

METHODOLOGY

A survey of plants that are commonly used by traditional healers for wound healing in Buhera District, Manicaland Province, Zimbabwe led to the identification of twenty one plants as having high efficacies at wound healing. Four of the plants were most frequently cited as used mostly in the form of ashes of the root, bark, or pods to treat different kinds of wounds. The plants parts were chopped, dried, and ground to powder. Some of the powder of *Asparagus laricinus* was exhaustively burnt to ash and part of the ash analyzed using XRF so that at least a qualitative description of the constituents of the ashes could be given. The rest of the ashes were dissolved in acidic media and analyzed using Atomic Absorption Spectroscopy leading to a quantitative description of the constituents. The ground powders of barks of *Dichrostachys cinerea* and *Xeroderis stuhlamannii*, and the root of *Asparagus africanus* were wet digested and submitted for atomic absorption spectroscopic determination for metal ions.

Experimental

The roots and a branch of *Asparagus laricinus* ***Burch*** *(Liliaceae)* plant were collected from Helencevale, Borrowdale, Harare, Zimbabwe and from Rusape, Manicaland Province, Zimbabwe in 1995, and identified at the Botanical Gardens, Ministry of Agriculture, Harare, Zimbabwe. Roots of *Asparagus africanus* were collected from Chihota, about 50km south of Harare, and also identified at the Botanical Gardens, Ministry of Agriculture, Harare, Zimbabwe.

The Pods of *Dichrostachys cinerea* and bark *Xeroderis stuhlamannii*, together with samples of the respective plant shoots were collected from Buhera, Manicaland Province and identified at the Botanical Gardens, Ministry of Agriculture, Harare.

Sample treatment

The four samples were separately dried in the shade, chopped, and ground to powder.

Roots of Asparagus laricinus

Asparagus laricinus ground root powder samples (2 kg) each from Hellensvale and Rusape were burnt in separate porcelain dishes (Bunsen burner, 12 hours, fume hood) yielding a grey ash (257 and 253g, respectively). 40g of the ash from each center were submitted for XRF oxides determination (Institute of Mining Research, University of Zimbabwe) (table 1). 200g of the remaining ashes from each of the two places was exhaustively extracted with water, the extracts filtered and freeze-dried, affording white powders (67 and 69g, respectively). These were also submitted for XRF oxides analysis giving results which were identical to those shown in Table 1. The residues left after the water extraction were visually examined. The residues from ashes of the sample from Hellensvale revealed the presence of yellow solids which were not observed in the residues of the sample from Rusape. Both residues were air-dried giving grey-black solids (124 and 5 g, respecively). These were submitted for gold assaying at the Institute of Mining Research, University of Zimbabwe. Gold (13mg) was recovered from the sample from Helensvale, but none from the sample from Rusape. Some of the ash (5g of each) was heated with dilute nitric acid (75 ml, 10 min.), filtered and the filtrate made to 100 ml with distilled de-ionized water and submitted for atomic absorption spectroscopy (Table 2).

Roots of Asparagus africanus

Asparagus africanus ground root powder (500g) was burnt in a porcelain dish (Bunsen burner, 12 hours, fume hood) yielding a grey ash (64g). Part of the ash (50g) was exhaustively extracted with water, the extract filtered under reduced pressure (water pump), freeze dried, affording a white powder (22g) and the powder submitted for AA spectroscopic metals analysis following standard sample handling procedures and instrument parameters (Table 2). Some of the ash (5g) was heated with dilute nitric acid (75 ml, 10 min.), filtered and the filtrate made to 100 ml with distilled de-ionized water and submitted for atomic absorption spectroscopy (Table 2).

Pods of *Dichrostachys cinerea* and Bark of *Xeroderis stuhlamannii*

The pods of *Dichrostachys cinerea* and the bark of *Xeroderis stuhlamannii* were separately chopped to pieces and dried in the shade in the Chemistry department, Faculty of Science, University of Zimbabwe, Harare. The dried samples were ground to powders using a mortar and pestle in the Department of Science and Maths Education, University of Zimbabwe, Harare, Zimbabwe. The ground bark powder of *Xeroderis stuhlamannii,* the ground root of *Asparagus africanus* and the ground pod powder of *Dichrostchys cinerea* were wet digested with acids.

Wet digestion of ground powders

Each ground powder (5.0 g) was accurately weighed and transferred into a 100 ml Kjaldahl flask and 5 ml of concentrated nitric acid added. As soon as the initial reaction had subsided, each mixture was heated gently until the further reaction that ensued had subsided and the mixture was allowed to cool gradually. Concentrated sulphuric acid (8 ml) was added at such a rate as not to cause excessive frothing, then the mixture was heated for about 5 to 10 minutes until it darkened appreciably in colour. Concentrated nitric acid was slowly added in 1 to 2 ml portions, heating after each addition until the mixture darkened again. A small but not excessive amount of nitric acid was kept present throughout. The treatment was continued until the mixture did not darken on prolonged heating and until white fumes were evolved. This took 5 to 10 minutes. The solution was allowed to cool, 10 ml of water was added and the mixture boiled gently until white fumes were evolved again. Finally the solution was cooled and 5 ml of water added.

Atomic Absorption Spectroscopy

Elemental analysis of the solutions was carried out using atomic absorption spectroscopy, employing standard conditions for the different selected elements. The element selection was on the basis of preliminary XRF analysis and the expected use for the element in wound healing processes.

RESULTS AND DISCUSSION

Table 1. XRF Identification of Elements in the Ash of *Asparagus laricinus* and *Asparagus africanus*

aluminium	cadmium	cobalt	lead	manganese	sodium
antimony	calcium	copper	lithium	nickel	Silver
barium	chromium	iron	magnesium	potassium	tin and Zinc

The results (Table 2) demonstrate that the plants contain elements that play pivotal roles in wound healing processes, as well as elements that have no documented positive roles in wound healing. Besides calcium, magnesium, potassium, and silicon which are present in large quantities, most of the elements investigated are present in trace amounts and are reported in literature as important enzyme cofactors.

Table 2. Atomic absorption spectroscopy results on samples of *Asparagus africanus, Asparagus laricinus, Dichrostachys cinerea and Xeroderris stuhlmanni (ppm)*

Plant/metal	A. africanus	A. laricinus	D. cinerea	X. stuhlmanni
Antimony	49	36	ND	ND
Aluminium	650	350	130	220
Arsenic	50	34	ND	ND
Calcium	312	307	1400	2700
Cadmium	2.5	2.0	3.0	1.0
Chromium	28	27	ND	ND
Cobalt	8.0	6.4	9.0	5.0
Copper	96	73	7.0	8.0
Iron	130	137	150	140
Lead	139	128	3.0	2.0
Lithium	3.0	2.5	ND	ND
Magnesium	178	173	2700	310
Manganese	6.5	9.3	7.0	4.0
Nickel	32	36	40	39
Potassium	1180	1109	4800	4100
Silicon	960	863	840	750
Silver	16	19	4	5
Sodium	127	133	160	86
Tin	31	25	ND	ND
Zinc	103	97	ND	1.0

With the exception of zinc which has not been observed in *Xeroderis stuhlmanni* , all the elements which have been reported as being important for wound healing processes (Ca, Cu, Ni, Si, and Zn) [10] have been observed in the four plants. The failure to observe it in *Xeroderis stuhlmanni* might simply mean that it may be present in so low amounts as to be below the detection limits of the technique used. However, the observed levels in the plants where it was detected are low.

The possible roles of the elements which were observed in the four plants

Many consumers mistakenly assume that because herbal preparations are natural, they are safer, gentler, and less medicinal than conventional drugs although little has been scientifically confirmed regarding either the adverse or beneficial health effects of most of the herbal products sold or prescribed by ethnomedical practitioners [28]. There is, thus need to evaluate the metals and metal ions that are observed in the plants which are used in ethnomedicine.

Gold

The discovery of gold in the root of *Asparagus laricinus* collected from Hellensvale, and not in the root of the same plant that was collected from Rusape, nor in the root of *Asparagus africanus* which was collected from Chihota, might be intriguing. There is need for a more extensive survey of gold in the sub species to be able to come up with a possible explanation to the observation. The World Gold Council [29] reports that claim for the medicinal benefits of gold date back many thousands of years and that many ancient cultures (especially Egypt and India) used gold-based medical preparations. Work carried out after the Second World War demonstrated conclusively that gold drugs are effective in treating rheumatoid arthritis patients [29]. The discovery that phosphite supported gold complexes have excellent anti-tumour activity [30] further renders the discovery of gold in these plants the more interesting. The gold probably exists in the live plant in complexation with the organic ligands in the cell matrix. The possibility that the gold might have been present due to contamination of the sample with soil containing gold on the surface of the roots was dispelled when the samples were thoroughly cleaned with water before sample processing and the ashes were still found to contain gold. One of the uses to which traditional healers in Zimbabwe employ asparagus plants is in the treatment of arthritis, rheumatism, some cancers, and gout (unpublished work). Such uses are in keeping with historical uses of gold.

Silver

Silver is one of the trace metals which were found in the four plants under investigation. This metal has been used as a wound healing and anti-bacterial agent by civilizations throughout the world for thousands of years. Its medical, preservative and restorative powers can be traced as far back as the ancient Greece and the Roman Empires, having been employed as a germicide and antibiotic long before the development of modern pharmaceuticals. The use of silver as an antibacterial substance became widespread by the early 1900s, but lost to modern antibiotics during the 1930s due to the simplicity of manufacturing of the modern drugs. Notwithstanding, the use of silver in mainstream medicine such as the use of dilute silver nitrate in newborn babies' eyes to protect them from infection and the use of silvadine to fight infection in burn wounds has survived. The return of silver to conventional medicine began in the 1970s [31]. In the USA, certain forms of silver such as silver hydrosol, are sold as dietary mineral supplements, for maintaining and sustaining immune defenses in the presence of emerging strains of bacterial, viral and fungal infections, and for tissue regeneration support. These four plants under investigation are also used for immune boosting purposes by traditional healers in Zimbabwe (Unpublished work). Silver sulfadiazine is a powerful compound accepted by the majority of the medical community in North America for burn victims to kill bacteria and allow the body to naturally regenerate the burn area [32]. Thus the presence of silver in these plants vindicates the potential for the plants as wound healing agents and restoratives.

Copper, iron, magnesium, zinc

Whereas silver is known in connection with its antibacterial effects, other metals also found in these plants such as copper, iron, magnesium, and zinc are renowned for the role they play in actively promoting wound healing [33]. Wounds are a part of life, and wound healing affects everyone at some time. Non-healing, chronic wounds impair the quality of life of many people. The mediators of vessel formation, a critical process to each stage of wound healing, are not known with certainty, but iron, an obligate requirement for life and a key to wound healing, may play a role [33]. Iron deprivation reduces the activity of the ribonucleotide reductase necessary for DNA synthesis, decreases the expression of cyclones A, B, & D and results in hypophosphorylation of the retinoblastoma protein [33]. As has been pointed out [9][10] metalloenzymes play a pivotal role in wound healing. Copper sensitive pathways which regulate key mediators in wound healing such as angiogenesis and extracellular matrix remodeling have been studied and copper-based therapies may represent a feasible approach to promote dermal wound-healing [34]. Three of these metals and metal ions are found in the four plants under discussion. Appreciable levels of zinc are found in the two Asparagus plants, only a trace amount of zinc is found in *Xeroderis stuhlmanni* and none is detected in *Dichrostachys cinerea.* The presence of these metals in these plants points out towards the value of the plants for wound healing intervention. However, the failure to observe zinc in the sample of *Dichrostachys cinerea* was disturbing because zinc has been described as being very important for wound healing and yet a plant renowned to be a potent wound healing agent did not contain zinc. It might be that the zinc levels were below the detecting limits of the technique used. Zinc, together with other elements, acts as cofactor for various enzymes during wound healing. Zinc produces a beneficial effect on the healing of ulcers by modulating the cutaneous inflammation and accelerates re-epithelialisation process [35]. It stimulates the proliferation of epidermal cells and plays an important role in skin physiology. Its deficiency results in impaired immuneresponse and decreases protein and collagen synthesis [35][36]. Zinc deficiency increases the time for wound closure and decreases wound strength. It has, thus, been used as a topical application to treat diaper rash, bedsores, ulcers, and incision wounds. Although the role of zinc in wound healing has been investigated since the 1930s the mechanism by which it affects wound healing is not yet clear [37].

Alkali metals and other trace elements

Calcium, potassium and sodium ions, observed in all the plants under investigation, are important for muscle contraction including ventricular arrhythmias and contractile dysfunction [38], and maintaining fluid balance [39]. These ions are important for the general metabolic functions of the body and their supply through intake of the plant medications can only be beneficial.

Calcium prohibits bacterial reproduction on wound surfaces [40]. Topical application of calcium increases proepithelialisation of the wound in a rate that is directly proportional to the calcium concentration on the wound surface. It reacts with magnesium ions on the surface of the wound to form chelates which have antibiotic properties.

The other trace elements which are observed in the plants include chromium which aids in glucose metabolism and regulates blood sugar, copper which aids in normal red blood cell and connective tissue formation, magnesium which activates over 100 enzymes and helps nerve and muscle function, and zinc which is an essential part of more than 200 enzymes involved in digestion, metabolism, reproduction and wound healing [39]. Thus the presence of these elements could be beneficial to wound healing. However, chromium was observed in samples of the two *Asparagus plants* but not in those of *D. cinerea and X. stuhlumann,* notwithstanding the two plants' reputation as wound healing agents in traditional medicine in Zimbabwe.

Non-essential toxic elements

Excessive levels of some of the non-essential toxic elements which have been observed in the plant samples such as aluminium, cadmium, and lead can have unbalancing effects on trace element balances in the body cells [10].

Cadmium

Cadmium, an element known to cause hypertension, cancer, and immune disorders, as well as a classical stress agent with a half-life of between 10-30 years in the human body compared to lead with a half-life of between 30-100 days, has also been implicated in learning disabilities besides being very toxic on its own as well as increasing the toxicity of other agents [11]. Public health issues concerning cadmium include renal function perturbation, and bone function risk. The chronic health issues associated with exposure to cadmium and its compounds are well documented [41]. The cadmium level observed in the plants under discussion is low (1.0-3.0 ppm), but its cumulative effects over the years could be considerable. However, traditional medicine patients are not likely to take the medication continuously and the amount of medication taken at any one time is minimal.

Lead

Metallic lead has been known since its recovery from the temple of Abydus in Upper Egypt (4000 BC). Lead and its compounds are not known to be associated with any beneficial health effects whatsoever, and excessive amounts have been found to be very harmful. However, although the poisonous effects of lead were known even in ancient times, it was actually prescribed for medicinal purposes, such as to treat indigestion. The Egyptians, Hippocrates & others, also considered it therapeutic, & Pliny describes several remedies which involves lead: "for the removal of scars, and as an ingredient in plasters, for ulcers, and for the eyes, etc" [42]. Incidentally, some traditional healers in Zimbabwe use Asparagus plants to remove scars (unpublished work).

Antimony

Antimony was observed in the Asparagus plants, but not in the other two plants. The medicinal use of antimony dates back to ancient times, treating tremours, dropsy, spinal irritation, wooping cough, and chronic inflammation of the chest. Antimony compounds are known to interact with sulfhydryl groups on proteins in the parasites. The bioavailability of antimony (III) compounds is low because their solubility is low [43]. Inorganic antimony appears to be rapidly excreted in urine and feces. Biliary excretion seems to be limited to trivalent forms of antimony, while pentavalent compounds' excretion occurs via the urine. Trivalent antimony is taken up by red blood cells. Background serum, blood and urine concentrations are[41]. No issues of the type reported for arsenic have been identified for antimony [44].

Arsenic

Arsenic was observed in the Asparagus plants, but not in the other two plants. Arsenic has been implicated in human foetal and infant mortality [45], and consumption of some herbal supplements has been reported to lead to worsening alopecia and memory loss, rash, increasing fatigue, nausea and vomiting [44]. However, these reports refer to prolonged arsenic intake or exposure. The traditional healers normally prescribe small amounts of root over a few days at a time. Arsenic symptoms are known to resolve within weeks of discontinuing arsenic intake [44]. Public health issues related to high level chronic inorganic arsenic ingestion include skin and internal cancers, skin leisions, neurological outcomes, cardiovascular diseases, gastrointestinal disorders.

Chronic health effects of arsenic

Hyperkeratosis, hyperpigmentation and skin cancer have been associated with the consumption of drinking water containing inorganic arsenic. These clinicopathological findings have been documented for outbreaks in Taiwan, Japan, Agentina, Bangal & Bangladesh. Concentrations above 50μg/L in the drinking water were common. Ingestion of inorganic arsenic is linked to elevated risks of bladder, kidney, lung, and liver cancers [41].

Chronic exposure to arsenic by ingestion or inhalation has been associated with peripheral neuropathy, axonal degeneration and encephalopathy. It appears that neurological outcomes are not seen for arsenic intakes of less than 10μg/kg/day. Vascular disease has been associated with occupational exposure & ingestion of arsenic of 14 to 65 μg As/kg/day. Nausea, vomiting, diarrhea, anorexia, weight loss, hepatomegaly, jaundice, pancreatitis and liver cirrhosis have been reported for chronic intake of levels of arsenic above 10 μg /kg/day. Like lead, arsenic compounds constitute systemic poisons. The intake levels at which no non-cancer adverse outcomes are known appear to be ≤10 μg/kg/day. Gastrointestinal absorption rates of inorganic arsenic are not well established, but appear to be extensive for some compounds. Arsenic was observed in the ash of Asparagus at 50ppm.

Cobalt

Cobalt is a trace element essential in the nutrition of ruminants and in the maturation of human red blood cells in the form of vitamin B_{12}, the only vitamin known to contain such a heavy element (Encyclopaedia Britannica). All the four plants contain detectable amounts of cobalt.

Nickel

Nickel was observed in the extracts of the four plants under discussion. Two principal adverse effects associated with nickel are skin allergy and lung or nasal cancer. As many as 10-20% of women and 1-2% of men have been sensitized to nickel due to both direct and prolonged skin contact with nickel in cheap-plated earrings or other jewelry, allowing nickel to dissolve and penetrate the skin and cause allergic reactions. Lung cancers are predominantly associated with breathing high concentrations (10mg Ni m^{-3}) or airborne insoluble oxides and sulphides. Nickel is a natural constituent of many foods and is also a trace element in drinking water. Thus we eat and drink some nickel every day in our normal diets along with many other minerals. Both soluble and insoluble nickel compounds can cause DNA breaks and DNA-protein crosslink *in vivo*. Nickel compounds are considered as human carcinogens based on epidermiological studies, mechanistic information and evidence from animal studies. The release of nickel ions is responsible for the genetoxic and carcinogenic effects of all forms of nickel. Nickel ions from readily soluble nickel salts are slowly taken up into mammalian cells through plasma membrane ion channels. Nickel metal and the less soluble nickel sulphides and oxides are taken up by phargocytosis. A much higher intracellular bioavailability of poorly soluble nickel compounds as compared to that of readily soluble nickel salts explains the higher potency of poorly soluble nickel salts and insoluble nickel. Oral exposure to nickel has not been reported as being associated with carcinogenic risk. However, since nickel ions are the active species responsible for tumour inductions and nickel ions may also be absorbed after oral exposure to nickel salts [46], it is advisable to be cautious about the availability of nickel in these plants.

Lithium

Traces of lithium were observed in the samples of the two *Asparagus* plants but not in the *D. cinerea* and *X. stuhlmanni* samples.

CONCLUSION

Traditional healers normally prescribe one teaspoon of powdered plant part to be taken three times per day in porridge or as tea, etc. or a few pieces of plant part to be taken as a decoction, or in the case of ashes, enough ash to cover the wound. The medication is not normally taken over long periods of time, the prescription being for one to two weeks. The amount of metals and metal ions consumed by the patient following normal treatment regimes is low. The existence of heavy metals in the plants might lead environmentalists to consider employing them, especially the Asparagus plants, as scavengers of undesirable heavy metals from the soil. Thus, the objectives of this study, to document the metals and metal ions in the ashes of the root of *Asparagus laricinus* and *Asparagus africanus*, the bark of *Dichrostatchys cinerea* and the bark of *Xeroderis stuhlamannii*, and attempt to explain their possible medicinal roles in wound healing as used by traditional healers in Zimbabwe have been met.

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