INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 9, No. 1, p. 215-224, 2016

RESEARCH PAPER OPEN ACCESS

How medicinal herbs become hazardous to human health?

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Key words: Medicinal herbs, Human health, Hazards.

http://dx.doi.org/10.12692/ijb/9.1.215-224 Article published on July 29, 2016

Abstract

Risks of medicinal herbs from their inception, identification, collection, handling, drying, processing, packaging, labeling, storing and finally selling to consumers is highlighted with especial focus on their toxicity to human health. Medicinal herbs under substandard environment may raise many concerns about human health. This review indicates that medicinal herbs are only safe and effective to human health when grown in friendly environments i.e. the environment free from synthetic pesticides, chemical fertilizers, heavy metals, impure and unsterilized manures, municipal wastes and salts. Further, this review also specifies about post-harvest practices that may also influence the efficacy of the herbs. It is concluded that the medicinal herbs have only become consumable and includable in herbal medicine system, when they are grown in non-toxic environment.

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Introduction

Plants get their food from soil, water and air (Rashid, 1996; Das, 2011). Plants obtain carbon (C), hydrogen (H) and oxygen (O) from air and water. While, all other macro (NPK), secondary (Ca, Mg and S) and micronutrient elements (Zn, Cu, Mn, Fe, B, Cl and Mo) are taken up largely from soil (Rashid, 1996). Due to injudicious use and industrial activities these sources are depleted and/or polluted enough to provide toxic and hazardous elements to plants instead of supplying only adequate amount of pure essential nutrients. Much of the agricultural and fertile lands have become salt-affected and water-logged (Qureshi and Barret-Lennard, 1998) in almost all regions of the world (Ghassemi *et al*., 1995). Air is smoky, dusty and polluted with metal pollutants (Pb, Zn, Ni, Cr, Cd, As, etc.) and poisonous gases like CO, NO_2, SO_2, O_3, HFC134a, HFC23 (Hydrofluorocarbon), CH_4 (Methane), SF_6 (Sulphur hexafluoride), etc. (Agarwal, 2002), natural waters in rivers and lakes are polluted with pathogens, metals, pesticides, etc. (Agarwal, 2002). Groundwater quality at majority of places in the world is deteriorated and unsafe enough to be exploited for drinking and/ or irrigating major and minor field crops including medicinal herbs (Liu, *et al*., 2007; Latif *et al*., 2008).

About 80% of the population of the developing countries still uses traditional medicines for their health care. The rational use of traditional medicines in primary health care is not based on the guidelines developed by the World Health Organization (WHO).

Using poisonous plant species

More than 350, 000 plant species have been identified by biologists on the earth (Breidahl, 1994). Some of these plant species such as *Ricinus communis*, *Melia azedarach*, *Mucuna pruritum, Zigadenus* species, *Lantana camara, Hippomane mancinella, Nerium oleander, Pangiumedule, Jatropha curcas, Conium maculatum, Toxicodendron radicans, Toxicodendron diversibba, Toxicodendron vernix, Abrus precatorius, Nux vomica, Campsis radicans, Cicuta maculate,* etc. are naturally poisonous (Thomas and Schiano, 1998), Their deliberate or by mistake contact, ingestion, absorption/inhalation, etc. can cause painful skin irritation, internal poisoning as well as fatalities (Furbee and Wermuth, 1997). Hence the use of naturally poisonous plant species in herbal medicine system must be avoided.

Medicinal herbs become toxic when they are treated with pesticides and other hazardous chemicals

Indiscriminate use of pesticides (fungicides, insecticides, herbicides/weed killers, etc.) has become a part of commercial agriculture which has led to destroy nature's balance and pollute especially soil, water and environment. Applying pesticides increases maxima residue limits (MRL) in green leafy vegetables (Singh and Chawla 1988; Abo-El-Seoud *et al*., 2009; Esturk *et al*., 2014), fruits (Adeyeye and Osibanjo, 1999), other agricultural commodities (Soliman, 2001; Ozbey and Uygun, 2007; Walia and Koul, 2008) and medicinal herbs (Abou-Arab and Abou Donia, 2001). Residues of organ phosphorus and organ chlorine pesticides in some Egyptian spices and medicinal plants like *Jews mallow, dill, celery, tea, caraway, chamomile, saffron, peppermint, karkade*, etc. have been observed by Abou-Arab and Abou-Donia (2001). They found that with the exception of Malathion, which was generally higher in almost all analyzed samples, there was a significant difference between plant species for containing residues of different pesticides. The concentration of Lindane, Aldrin, Dieldrin, DDT, Chlordane and Endrin was higher in Chamomile samples, Aldrin and Dieldrin was higher in Karkade and Chlordane remained higher in Peppermint samples. In addition to accumulation of pesticide residues, plants change their behavior with pesticide application. Adverse effect of pesticides on plasmalemma (cell membrane responsible for potassium/sodium selectivity) has also been observed (Schefczik and Simonis, 1980). This indicates that plants treated with pesticides not only accumulate residues but they also accumulate toxic elements such as Na^+ (cytotoxic) instead of K^+ (a nutrient element). The information suggests that the medicinal plants if are treated with pesticides must not be included in herbal medicine system,

because pesticides are hazardous to health, results in lower down memory, stamina, motor skills, etc. (Anonymous, 2003). It is also interesting to know that some plants seem like the most peaceful organisms, but nonetheless they have their own form of defensive mechanisms against insect attack (Wink, 1988; War *et al.*, 2012). In addition, plants also release volatile organic compounds that attract the natural enemies of the herbivores (War *et al.*, 2012), hence each plant may not have need of pesticide applications.

Medicinal herbs become toxic when they are treated with chemical fertilizers and manures

Modern agriculture has substantially replaced organic and natural manures with synthetic inorganic fertilizers which are considered not as environmentally safe as organic and natural manures are, because synthetic inorganic fertilizers produce acidity, alkalinity and salinity in soil (Das, 2011). Growers feed their plants with plenty of nitrogen, phosphorus, potassium and some other micronutrients such as, Zn and B through synthetic inorganic chemical fertilizers.

These fertilizers are applied to plants through soil, hydroponics or foliar spray. Such practice of growers makes the elements available all at once in massive concentration hazardous to health and environment (Hills, 1989). In addition to labeled nutrient elements, majority of inorganic fertilizers also contain traces of other toxic elements and radioactive heavy metals (Barisic *et al.,* 1992; Scholten and Timmermans 1992; Hussein, 1994; Taylor, 1997; Bodelier *et al.*, 1999; Monique, *et al.*, 2008) conditioners, neutralizers of residual acidity, fillers (Das, 2011) and other compounds toxic to plants such as biuret ($NH_2CONHCONH_2.H_2O$), etc. (James and Oomen, 1987). Application of manures and organic fertilizers obtain from those animals and poultry birds who regularly receive certain drugs, boosters, vaccines, synthetic feeds, etc. may not be safe to fertilize medicinally important plant species. Some highly toxic drugs, boosters and vaccines are being sold in the market and practiced by veterinarians to control over diseases, reduce mortality and boost up milk and meat production (Patel and Heldens, 2009). Similarly some manure may contain quantities of toxic elements which can be accumulated to a danger level in the soil (Hills, 1989). Natural manures sometimes contain pathogens (Guan and Holley, 2003) and for safety they may not be incorporated or spread in the field without sterilization or treatment (Colborn *et al.,* 1993). Although, night soils (human excrement) and urban compost are rich in elements, most of the people do not want to use plant material or consume medicinal herbs if they are raised on night soils with manure and/or with urban compost due to their prejudice (Das, 20011).

Medicinal herbs become toxic when they are exposed to polluted environment

Plants in polluted environment, especially in the environment contaminated with heavy metals may accumulate certain toxic elements (Taylor, 1997) and may synthesize compounds which are considered hazardous to health and environment (Hills, 1989).

Similarly medicinal herbs, if are grown in polluted and contaminated environment may accumulate toxic elements like Pb, Co, Hg, Cr, As, etc., (Baker and Whiting, 2002) and synthesize phytochemicals or compounds hazardous to human health. Therefore, before putting medicinal plants in herbal medicine system, one should make sure that they have been grown or raised in fresh and pollution free environment and will be safe and more efficient for patients (Cao *et al.*, 2009).

Efficacy and safety of medicinal plant may vary with ecology. In polluted environment, plants remain under stress and they try to grow, develop and survive in such an adverse environment, for that they uptake toxic elements which may lead them to synthesize compounds hazardous to health (Thomas and Schiano, 1998). Medicinal plants and herbs grown in polluted environment can be fatal. Each year more than 100,000 cases of exposure to toxic plants are registered to poison centers in USA (Furbee and Wermuth, 1997).

Medicinal herbs become toxic if they are raised with urban wastes

Sewage and sludge are major sources of heavy metals like Pb, Hg, Cr, As, Ni, etc. and pathogens (Li, *et al*., 2008; Yang *et al*., 2009). Generally carminatives like ginger, cloves, coriander, mint, hurbu, garlic, turmeric, etc. are particularly raised with untreated urban wastes (Miguel, *et al*., 1998; Miguel, *et al*., 2007). Raising plants with such sewage and sludge may increase pathogens and concentrations of toxic elements hazardous to human health. It is therefore suggested that medicinal flora if are raised with urban wastes (sewage and sludge) will become unsafe and ineffective to be consumed directly as a medicine or to be used for extracting essential natural drugs.

Medicinal herbs become toxic if they are raised under salty environment

Salt-affected soils contain elements toxic to plants in excess. Salinity of soil or water is one of major stress obstacles to increase production in plant growing areas throughout the world and especially in arid and semi-arid regions as can severely limit plant production (Jamil *et al*., 2006). According to Sreenivasulu *et al*., (2007), the adverse effects of salts on plant growth may be divided into three broad categories: (i) a reduction in osmotic potential of the soil solution that reduces plant available water and thus creates a water stress in plants, (ii) a deterioration in the physical structure of the soil such that water permeability and soil aeration are diminished, and (iii) increase in the concentration of the certain ions that have an inhibitory effect on plant metabolism (specific ion toxicity) and mineral nutrient imbalances and deficiencies or (iv) a combination of these factors. Plants change their physiology and biochemical behavior to tolerate salty environment (Yancey, 1994; McNeil *et al*., 1999). Some plants synthesize osmo-protectants under saline conditions (Garcia *et al*., 1997). Although, some of these osmo-protectants are well known, such as Glycine-betaine, Proline, Carnitine, Choline, etc. (Robert *et al*., 2000), while in addition to known organic compounds, plants may synthesize other unknown phytochemical/osmoprotectant compounds (biosynthesis of plants) which may need to be isolated and identified by the researchers.

The data presented by various workers (Miceli *et al*., 2003; Sosa, *et al*., 2005; Omami, *et al*., 2006) on influence of salts stress on medicinal plants give a clue that in addition to known osmo-protectants, plants possibly synthesize other phytochemicals and compounds which need to be known that they are safe enough and non-toxic to human health. Hence care must be taken before obtaining natural drugs from the medicinal herbs and plants grown in salty environment.

Medicinal herbs become toxic if they are raised in different habitats

Geographical distribution is also responsible for variation in phytochemical contents of medicinal plants (Singh, 2008). Plant of one habitat may or may not produce the similar amount of phytochemicals in another habitat (Kumar *et al*., 2009). For example plants of different latitudes and altitudes produce drugs of variable quantity and quality (Martz *et al*., 2009).

It is also evident from the study of Raina *et al*., (2007) who found variation in phytochemical contents of *Andrographis paniculata* collected from different parts of India. The cultivation of medicinal plants at their original habitat represents the most suitable means to comply with the increasing demand for medicinal plants and to avoid the depletion of natural sources (Bonati, 1980).

Martz *et al*., (2009), in their study, described the soluble phenolic and terpenoid composition of juniper needles collected in Finland (n=125) and demonstrate that the concentration of these compounds clearly increased with latitude and altitude, however, a stronger latitudinal effect (a higher content of monoterpenoids, proanthocyanidins, and flavonols in northern latitudes). It is therefore, advised that medicinal plants must be grown at their original habitat.

Table 1. Different reviewers' data/observations/remarks for pesticide impact on medicinal plants.

S.NO.	Name of Reviewer	Remarks
1	Abou-Arab and Abou-Donia, 2001	Use of pesticides increases maxima residue limit (MRL) in Medicinal herbs.
2	Schefczik and Simonis, 1980	Pesticides showed adverse effects on plasmalemma.
3	Walley *et al*., 2006	Poor root hair development, shoot yellowing and reduced plant growth
4	Rockets, 2007	Reduction of symbiotic chemical signaling results in reduced nitrogen fixation and thus reduced yields
5	Hurley, 1998	Organo chlorine insecticides could pollute the tissues of virtually every life form on the earth, the air, the lakes and the oceans,
Indirect effects		
1	Arias and Fabra, 1993; Fabra *et al*., 1997	2,4-D reduces nitrogen fixation by the bacteria that live on the roots of bean plants
2	Singh and Singh, 1989; Tözüm-Çalgan and Sivaci-Güner, 1993	Reduces the growth and activity of nitrogen-fixing blue-green algae
3	Frankenbergerand Tabatabai, 1991, Martens and Bremner, 1993	Inhibits the transformation of ammonia into nitrates by soil bacteria
4	Kelley and South, 1978	Oryzalin and Trifluralin (herbicides) both inhibited the growth of certain species of mycorrhizal fungi (grow with the plant roots and helps in nutrient uptake)
5	Cornell University, 2007	Pesticides to crops that are in bloom can kill honeybees, which act as pollinators

Medicinal herbs become toxic if they are expired

Ingesting expired herbs can also become poisonous and toxic to public health (Bandaranayake, 2006). Both the quantity and activity of compound contained by medicinal herbs can be influenced by their shelf-life (Singh, 2008). The findings of Hall, (1970); Chaudhry, (1980) Farooq, (2009) also indicate that the post-harvest storage practices in developing countries, like Pakistan are not up to the standard. Medicinally important plant material and herbs remain in the stores for long duration; until unless they are not sold to the consumers; they remain there in the stores. Use of iron or metallic, old rusty containers and shelves for storing medicinal herbs are a common practice of herbal stores in developing countries. Hence in addition to long shelf life, the old rusty irony or metallic containers used for packing and storing herbs may add some more toxic metals/elements to it, because as per standards specified by WHO, (1998) "the container and its closure must not interact physically or chemically with the material within anyway that affect quality".

Medicinal herbs become toxic when they are not properly processed and dried

The way to dry medicinal herbs largely influences the quantity and quality of drugs present (Muller *et al*., 2006). Compared to direct sunshine, drying medicinal herbs under shade has been found very effective and useful way (Heeger, 1989). However the quantity of herbal production is a major factor in deciding to select the better options while viewing other factors such as, availability of new technologies and pharmaceutical quality standards also considered for drying of medicinal herbs. Drying medicinal herbs naturally, i.e. drying without the use of energy either in the field or

in shades should only be considered for drying of small quantities. However, when a larger amount of medicinal herbs is to be dried, the use of modern technical drying is compulsory.

For the preservation of active ingredients of medicinal plant materials, comparatively low drying temperatures are recommended and, as a result, the drying duration is comparably long. The method used for drying medicinal plants also affects on the quality of the drug. Thus, before finalizing any technique for drying medicinal plant material, the design of dryer, its working mechanism, energy consumption, drug quality assurance must be thoroughly assessed.

Absence/gap in regulation for safety, quality and efficacy of medicinal herbs

Many people often use and prefer herbal medicines instead of allopathic and acupuncture system of treatment in developing countries. Moreover, the involvement of inexperienced persons in this profession raises many questions about the authenticity/validity of the drug that come under their own brand name or formulation without any registration or recognized legal evidence. They either intentionally hide their formulas or deliver to their descendants or followers of their own choices, so that the fame of formulation should remain under their patronage due to their professional jealousy or may be due to their ill rituals.

Thus the absence of proper legal policy for herbal medicines' trade in aspects such as cultivation, collection, processing and storage provides no guarantee, while environmental pollution, misidentification and adulteration further aggravated the problem (Street *et al*., 2010).

Hence, it is mandatory to address such challenges so that a proper regulatory mechanism in terms of correct identification, scientifically approved methods for processing and storage with hygienically safe standards under a well-documented and legally registered and monitored system and a time to time scientific up gradation and legal amendments must be brought into practice because after all it is a matter of public health.

The hidden and lost information of traditional medicines must be recapped and the endanger species should be conserved. As a new emerging field in ethno pharmacology, treatment guidelines and evidence-based evaluation guidelines for ethnoergogenics, and protection guidelines of intellectual property for ethnoergogenics should be developed and put into practice according to guidelines of the WHO and WIPO (World Intellectual Property Organization), respectively (Kim,2005).

Conclusion

This review suggests that the medicinal herbs should be brought into scientific system of proper standardization before the consumer, because medicinal herbs are of same value as those in other systems of medicines for public health. It is of utmost importance that if all the drawbacks of the old system in herbal medicine are eradicated, then the authorized and hygienically safe use of these drugs may provide another better choice for consumers to take cheap natural drugs directly without considering the chemo toxic side effects. This can also promote our environment by growing these herbal medicines under standardized conditions without any chemical use.

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