ENTOMOREMEDIATION - A NOVEL *IN-SITU* BIOREMEDIATION APPROACH

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ABSTRACT

In this paper entomoremediation as a novel concept was critically projected as a bioremediation technique that needs to be harnessed in line with global realities of involving organisms like microorganisms and earthworms in soil decontamination. Entomoremediation is defined as a type of remediation in which insects are used in order to decontaminate a degraded soil. The candidacy of collembolans, ants, beetles and termites in entomoremediation is advocated because of their role as ecosystem engineers. The need for mass rearing of the insects to be used in proposed bioremediation is discussed. Bioremediation as a measure that requires interdisciplinary approach is emphasized. The need to use insects that are neither threatened or endangered in entomoremediation in order to achieve overall healthy balance of the soil environment is stressed.

Keywords: Entomoremediation, Bioremediation, Insects, Decontaminate, Degraded soil, Ecosystem

INTRODUCTION

Bioremediation is defined as the use of biological processes to degrade, break down, transform and / or essentially remove contaminants or impairments from soil and water (Donlon and Bauder, 1980). A lot of interest has been generated in developing *in situ* strategies for remediating environmental contaminants (Gerhardt *et al*., 2008). The advantages of *in situ* bioremediation techniques have been outlined by Donlon and Bauder (1980) while the overview of *ex situ* decontamination techniques for polluted soil has been discussed (Pavel and Gavrilescu, 2008) with their merits and demerits outlined.

Hitherto, bioremediation has traditionally been viewed as a technique that will stimulate the growth of microorganisms or provide conducive environment for their activity (Pavel and Gavrilescu, 2008) alongside the organisms involved in the bioremediation (Chukwura, 2012).

Soil is a fragile ecosystem Soil however can be contaminated by a number of factors including chemicals (e.g. petroleum products like hydrocarbons), pesticides and heavy metals and even anthropogenic factors in which the nature of the soil can be altered. A contaminated soil can constitute hazard not only to human health but can pose a threat to the ecosystem, with a lot of techniques emerging to remediate the soil on-site (Gimsing *et al*., 2004). In this paper the concept of entomoremediation as an *in situ* soil decontamination technique is advocated to add to the existing *in situ* and *ex situ* soil remediation techniques being harnessed all over the world.

MATERIALS AND METHODS

A comprehensive search was made from the Internet, various journal articles and textbooks for reports on the use of insects, insect parts and biochemicals for bioremediation in various parts of the world.

Such articles were assembled, studied and represented in this review.

RESULTS AND DISCUSSION

Entomoremediation – A Novel In Situ Soil Decontamination Technique: Literature is rich regarding the use of *in situ* and *ex situ* bioremediation measures for decontamination of the soil (Gimsing *et al.,* 2004; Gavrilescu, 2006; Pavel and Gavrilescu, 2008; Chukwura, 2012) but no mention has been made on the possibility of use of insects in soil decontamination. No name has also been given to describe the measure. This remediation measure can be called entomoremediation and the insects so utilized entomoremediators. Entomoremediation can be defined as a type of remediation in which insects are used in order decontaminate a degraded soil.

The candidacy of collembolans, beetles and termites is advocated in the proposed entomoremediation. These four groups of insects - collembolans, ants, beetles and termites have been classified as ecosystem engineers (Jones *et al*., 1994; Folgrait, 1998; Badejo *et al.,* 2004; Badejo, 2012; Ewuim *et al.,* 2012). The dung beetle, for example, which have also been implicated as ecosystem engineers and have been protected in several countires (Figure 1) (Boze *et al*., 2011; Ewuim *et al.,* 2012), can contribute to ecosystem health by enhancing nutrient cycling and fertilizing by aerating soil (Halffter and Matthews, 1966; Boze *et al.,* 2011). Entomoremediation for instance can be useful in decontaminating a soil polluted with heavy metals, after soil ecotoxicological risk assessment, already discussed by Van Gestel (2012). Just like plants are known to sequester certain elements in their tissues (Marscher, 1995; Justin *et al.,* 2011), most soil invertebrates have the capacity to sequester at least a portion of their heavy metal burden at least in such a way that it does no longer pose a risk (Van Gester, 2012). Soil invertebrates like collembolans and beetles use the midgut epithelium for storing metals (Van Gester, 2012). During moulting the renewal of the midgut epithelium allows these organisms to excrete excess metal (Hopkin, 1989; Van Gester, 2012).

Figure 1: Dung beetles are extremely important environmental engineers and even protected in various parts of the world (Garrison, 2002)

Mass Rearing of the Insects is Implicit: After the study of biological indices for example as noted by Knoepp *et al*. (2000) and the investigation of the soil ecotoxicity already reported by Van Gester (2012), mass rearing of the insect of choice is necessary either in the laboratory or field cages. The insect(s) of choice may be one or a combination of desired species from the four insects groups already advanced – collembolans, ants, beetles (e.g. dung beetles), and termites before their introduction into the field for decontamination. Mass rearing of these insects of choice in entomoremediation will achieve sustainability of the desired insect species that will be released in the field for decontamination. Apart from the dung beetles which have been mass reared (McKay, 1976; Hayakawa and Kamashita, 1990) and which have witnessed large scale release in the field (McKay, 1976) after rearing, termites including the African giant termites (*Macrotermes jeanneli*) have been mass reared in the laboratory and in the vivarium (Leuthold

et al., 2004). Instance of mass rearing of collembolans e.g. *Anurida granaria* by Lynch (2001) indicate that *A. granaria* is cosmopolitan and ideal, safe and harmless for import/export and invariably not threatened or endangered. Literature is however copious on the various insects so mass reared for various purposes but cannot be exhausted here.

Entomoremediation versus Vermi-remediation: It is being advanced that if earthworms which have been classified as ecosystem engineers by Badejo *et al*. (2004), Badejo (2011) and Ewuim *et al.* (2011) can have the capability of converting a 'wasteland' into 'wonderland' in vermiculture (Sinha *et al.,* 2008), the inclusion of entomoremediation for decontamination of soils polluted even by heavy metals is advocated. Earthworms also can bio-accumulate high concentrations of metals including heavy metals in their tissues without affecting their physiology (Ireland, 1983; Sinha *et al*., 2008).

As vermiremediation may prove very cost-effective and environmentally sustainable in handling polluted soils and sites contaminated with hydrocarbons even in few weeks to months (Sinha *et al.,* 2008), entomoremediation has the potential of decontaminating soils polluted with heavy metals and hydrocarbons provided that any routine ethical issues in the use of these invertebrates in the novel entomoremediation are observed and that the insect species involved are not threatened or endangered species as applicable in vermiremediation studies.

Conclusion: In total, bioremediation measures require interdisciplinary approach. Many organisms ranging from microorganisms to the earthworms that have played their role in the recovery of the degraded soils clearly demonstrate a universal effort to evolve cost-effective methods of utilizing the potentials in these groups of organisms in salvaging the soil environment. Harnessing of the potentials of insects that are not threatened or endangered in entomoremediation will further enhance the restoration of a healthy balance of the soil environment.

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