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Potential utilization of industrial waste as feed material for the growth and reproduction of earthworms

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ABSTRACT: The issue of managing organic waste such as animal waste and industrial waste has emerged as a result of the fast development in urbanization around the world. It can be hazardous to the environment and public health if these are not properly stored, collected, and disposed of. These biological wastes can be turned into nutrient-rich biofertilizers using the vermicomposting process. The bio-oxidative method includes the combined activity of earthworms and microbes. The pH, organic carbon, organic matter, and the C:N ratio of the various organic waste mixtures showed a declining tendency during this process but the content of nitrogen, available phosphorous and exchangeable potassium showed a rising trend as the vermicomposting time progressed. Maximum earthworm growth and reproduction were reported better in different feed materials prepared from industrial wastes. Therefore, the present review article is based on the knowledge of using earthworms to stabilize waste.

Keywords: Bio-fertilizer; Biological waste; Cane sugar bagasse; Distillery effluents; Industrial waste; Vermicomposting.

1. INTRODUCTION

Management of waste is considered one of the most severe environmental problems faced all over the world. Industry releases a wide range of compounds in a serious proportion and causes environmental pollution [1]. A huge quantity of water is consumed by all industries for various purposes and throws back almost an equal quantity of effluents that contain highly toxic material, dissolved or suspended form [2]. The major sources of water pollution are industrial effluents, which disturb the life cycle of living things on the earth. Sugar processing is one of the largest polluting industries in India, representing 19% of the world's all-out sugar production. For the economic development of India, a very important role is played by the sugar industry. Organic pollution which is released as a harmful effluent from sugar industries harms both aquatic as well as terrestrial ecosystems. Annually, more than 30 billion liters of spent wash are produced by 254 cane molasses-based distilleries solely in India, 0.2-1.8 m^3 of wastewater per ton of sugar cane generated [3]. In recent years, sewage sludge released from urban industrial localities has been tested by the potential of earthworms for the stabilization of this sludge [4]. Highly nutritive values obtained from sewage sludge are valuable for plants and hence application of these nutritive values is used as a soil conditioner or fertilizer [5]. The present-day time has tormented humankind with new issues because of industrialization and concurrent populace blast. Natural harm is presently accepting risky segments all over the world. It emerges because of quick industrialization, urbanization, transportation, overpopulation, and lack of public awareness. It causes a noteworthy imbalance in all-natural activities.

Vermicomposting is the acceptable strategy for changing organic waste into ecologically friendly items. It is a bio-oxidative procedure that involves the combined activity of earthworms and microbes. The final product, i.e vermicompost, is a granulated material with high porosity and water-holding capacity. It is produced using biowastes and farmyard wastes by introducing earthworms into it. Vermicomposting technology is neither created nor rehearsed in Benin, while this technology comprises one of the devices for the management of organic waste [6, 7]. Vermicomposting is a viable, vitality-productive reusing process. For recovery of organic fertilizer, including earthworms, it utilizes organic waste from urban, industrial, and agricultural areas. The achievability of utilizing worms for waste management, as well as a potential source of protein for animal nutrition depends on fundamental knowledge of the essential parameters administering the endurance, development, and reproduction of earthworm species. The reproductive potential of earthworms is affected by the quality and accessibility of nourishment [8]. A variety of organic matter consumed by these earthworms is generally appropriate for changing natural waste into valuable natural fertilizer [9]. The toxicity of industrial waste can be reduced by earthworm technology [10]. It includes the degradation of organic waste into stable material by combined activities among earthworms and microorganisms living in their gut [11-13]. The chloragocyte cells and the intestinal microflora of earthworms can diminish the genotoxicity of industrial wastes [14].

Vermicompost improves the physical, chemical, and natural properties of the soil just as and add to natural enhancement [15, 16]. During vermicomposting, the earthworm increases the total Kjeldahl nitrogen, total accessible phosphorus, total potassium, and total calcium level but decreases the C:N proportion, complete natural carbon, pH, and electrical conductivity [17, 18]. It was also reported that the earthworm increases the fundamental micronutrients for the plant, plant growth hormones, enzymes, and nutrients [19-21]. Animal dung with different combinations of organic wastes like water hyacinth, agro/kitchen wastes, paper factory ooze, textile mill sludges, etc. are better for the growth and development of worms, which is essential for bio-conversion of organic waste [22].

2. INDUSTRIAL WASTE

Industrialization is accepted to cause a wide range of contamination issues as parity in the ecosystem is influenced by the release of hazardous waste into the environment, threatening the survival of all living beings [23]. The application of industrial waste directly as a fertilizer on horticultural fields can also harm humans and useful organisms in the ecosystem [24]. An enormous number of industrial wastes are vermicomposted and changed over into natural compost, including paper mill sludge [25], sewage sludge [26], textile industry waste [27, 28], winery and distillery waste [29, 30], tannery industry waste [31, 32], olive mill waste [33], beverage mill waste [34], agro mill waste [4] and sewage sludge [35] (Figure 1).

Vermicomposting is the way toward delivering fertilizer by using earthworms to transform the organic waste into high-quality manure that comprises the most worm cast in addition to decayed organic matter [36, 37]. It assists with changing over the organic waste (agro-waste, animal waste, and domestic refuse) into profoundly supplementing manure for plants and soil [38].

Figure 1. Different industrial wastes released in the environment.

The microbial decomposition of these wastes produces an unpleasant smell at the contamination level, causing several diseases that create serious human and domesticated animal medical issues [39]. Industrial sludge and livestock excreta are likewise major issues for the general public [17]. Kalpan et al. [40] reported that heavy metal pollutants caused environmental pollution, which is a major worldwide issue presenting a genuine hazard to animals and human well-being. Various researchers have tested earthworm-prepared waste, usually called vermicompost, in the horticulture and agricultural industries [41, 42]. In the field, the worm helps alleviate environmental pollution and participates in bio-accumulation and bio-remediation processes [43].

Worldwide, for the production of sugar, India ranks among the top countries. The sugar industry plays a significant role in the monetary improvement of India, but the effluent discharged produces a high level of organic pollution in both aquatic and terrestrial ecosystems. Among the waste-releasing industries, sugar factories assume a significant role in polluting water bodies. Every year India produces about 270 million tons of sugar cane [44]. Pressmud, bagasse, sugar beet mud, and pulp, are these wastes produced by the sugar industry [28]. Baskeran et al. [45] reported that the sugar factory assumes a significant role in contaminating the water bodies and land by releasing a lot of wastewater as effluents. The sugar factory effluents are having a higher measure of suspended solids, dissolved solids, BOD, COD, chloride sulphate, nitrates, calcium, and magnesium. The ceaseless utilization of these effluents harmfully affects the harvest when utilized in the water system.

3. CANE SUGAR BAGASSE

Bagasse is the fibrous waste produced inside the sugarcane juice extraction process. It constitutes cellulose (50%), hemicellulose (25%), and lignin (25%) [46]. The burning of sugarcane bagasse and leaves produces heat and power in places that are tropical or subtropical [47]. Since it only releases atmospheric carbon that has already been sequestered [48], its combustion can be regarded as sustainable [49]. Brazil produces up to 10 million tons of ash per year [50] from the combustion of sugarcane leaves and bagasse, which account for around 6% of the country's electricity production [51].

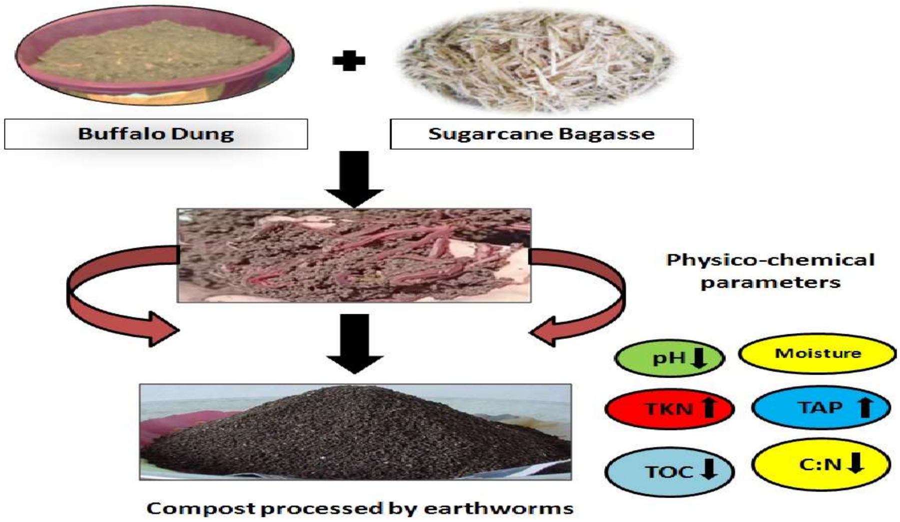

Figure 2. Changes in physico-chemical parameters after the processing of earthworms.

4. DISTILLERY MILL EFFLUENTS

Distillery industries are high income paid as well as contamination stacked industry. The ethanol is delivered from molasses which comes out from sugar cane industry waste [52]. Production of ethyl alcohol in refineries and the development of sugar cane molasses comprises a significant industry in Asia and South America. The fluid distillery effluent stream is known as a spent wash. It is a dark brown colored highly organic effluent [53]. The majority of distilleries in India use molasses as a basic raw material, and around 86% of this raw material is changed over into spent wash after fermentation and distillation. The removal of refinery spent wash is of serious concern because of its enormous volume and high biological oxygen demand (BOD) and chemical oxygen demand (COD).

In the distillery effluents, different metals/nonmetals separately may not be harmful to the plants however in combination they might be dangerous. On the other hand, Zalawadia et al. [54] studied the inhibitory impact of the distillery in the mix with manure on plants just as on soil properties. The continuous use of distillery wastewater has been accounted for to have the capability of improving soil physical and chemical attributes and increasing the substance of organic carbon and nitrogen with a beneficial impact on soil quality more evident on ineffectively created soil-sandy soil [55-57]. Continuous effluent application on soil can likewise prompt an increase in the level of sodium and subsequently the electrical conductivity of the soil [56]. Pandey and Carny [58] also reported that the effluents from cane sugar industries and distilleries contain huge amounts of dissolved organic matter. The organic matter is promptly decomposed by biological action.

5. EARTHWORM

The earthworm is a common soil biota belonging to the phylum Annelida, class Oligochaeta. The earthworm is a hermaphrodite, bilaterally symmetrical, segmented worm, with an external gland (clitellum) for the production of egg case (cocoon), a sensory lobe in the front of the mouth (prostomium), and an anus at the end side of the body along with a small number of bristles (setae) on each segment. In general, earthworms are reported to improve the porosity and structural stability of the soil, encouraging the solid yield of the crop. Thus, the earthworms are asserted as 'ecosystem engineers' of soil [59]. Earthworms are a significant part of the terrestrial ecosystem and they represent around 60-80% of the total soil biomass. They play an important role in soil procedures, for example, improvement of soil structure, nutrient cycling, and decomposition of organic matter. Approximately 4400 species of earthworms are distributed all over the world. However, few species are utilized during the process of vermicomposting [60].

In 1881, Charles Darwin was viewed as the first modern scientific study of the significant role of earthworms in soil ecology. The United State of America in the early part of the 20th century was regarded as the start of vermicomposting. By the late 1940s, earthworm cultivators were advanced as a powerful technique for farmers to improve their soil fertility based on the logical utilization of vermicomposting [61]. Earthworm seems to be a potential tool to overcome or reduce both feed cost and waste removal challenges by change of negative wastes into useful materials. The recycling of waste through vermicomposting has been accounted for to decrease issues of removal of agricultural waste [62].

The importance of earthworms in the breakdown and incorporation of organic matter into the soil is well established [63]. The earthworm populace is affected by different factors (soil temperature, moisture, pH) and the accessibility of organic matter for nourishment, which may originate from plant residues and animal or human waste applied to the land. Some major physiological functions, for example, nutrition, immunity, survival, growth, and reproduction have been demonstrated to be disturbed by exposure to environmental contaminants [64].

Earthworms are the significant drivers of the procedure, molding the substrate and altering the biological activity [65, 66]. Throughout the world, earthworms play an important role in deciding the equalization of greenhouse gases from soil and their effect is relied upon to increment in the coming decades [67]. Broadly, earthworms are classified as soil-dwelling and composting types [68, 15, 69]. The earthworm can also classify based on their feeding and burrowing strategies into three ecological: epigeics (little dwellers and transformers), anecics (burrowers), and endogeics (soil feeders) as noted by Bouché [70].

6. EFFECT OF WASTE USED AS FEED MATERIAL ON EARTHWORMS

Singh et al. [71] demonstrated the vermicomposting of sludge from the distillery industry and recommended that 50:50 is the perfect waste mix of industrial sludge and cow dung as far as supplementing the nature of end material and earthworm development execution. Industrial sludge can be vermicomposted potentially if blended in with a massive material in a reasonable proportion. Suthar [72] used sawdust and cow dung as massive agents for vermicomposting trials of guar gum industry waste. He proposed that a 60:20:20 ratio of industrial sludge, cow dung and sawdust was an ideal mix to gain the maximum biopotential of earthworms.

Aquino et al. [73] studied the combination of different ratios of cattle dung and sugarcane bagasse in earthworm fecundity. Maximum reproduction was observed in the 1:1 and 3:1 ratio (Figure 2). A balanced ratio of C and N that is excellent for earthworms is necessary for vermicompost (in biomass, reproduction and reduction of mortality rate). Earthworms ingest different types of organic wastes which usually come from animals, crop waste, the wine industry, and sewage effluents [74]. Various earthworm species such as *Megascolex mauritii*, *Eisenia fetida*, *Eudrilus eugeniae*, *Perionyx excavatus*, *Lampito mauritii*, *Eisenia andriae*, *Lampito rubellus*, and *Drawida willsi* have been used in vermicomposting and have been described to grow in number and size during vermicomposting [75].

Sangwan et al. [24] have estimated the highest growth rate of *Eisenia fetida* at 100% cow dung. Significant growth and development of the earthworm *E. fetida* in combination with different animal dung and agro wastes has been reported by Chauhan and Singh [76]. The best growth of earthworm *E. fetida* during vermicomposting of press mud sludge mixed with cattle dung in 1:3 ratios [77]. Higher cocoon production and biomass gain by *E. fetida* were more in cattle waste than goat waste [78]. Jesika [79] reported that the life cycle of *Eudrilus eugeniae* was found to be superior in a paper waste substrate.

For the earthworm *Perionyx excavatus* culture, using the right food source is crucial for boosting growth and reproductive efficiency. When the banana plant trunk was severed, earthworm *P. excavates* reproductive performance increased [80]. High fecundity, low incubation period, excessive hatching success in anecic [81], or top soil worm *Lampito mauritii* are assumably adaptive strategies of 'r' opted worms to permit them to survive drastic environmental alteration in the topmost soil. According to research by Garg et al. [17] and Jaweira Siddique et al. [82], organic waste (press mud) has a higher C:N ratio and phosphorus content (2.5%) that supports better growth (length and biomass) and causes earlier maturation, differentiation of the clitellum, and release of cocoons in *L. mauritii* and *E. eugeniae* worms than worms fed with cow dung or clay loam soil. Monitoring the variables associated with quantitative and qualitative indices of the cocoon and hatchling generation allowed researchers to evaluate the reproductive efficiency of earthworms. It was performed by Reinecke and Viijoen [83].

7. CONCLUSION

Different waste generated from the sugar industry in the form of press mud, bagasse, sugar beet mud, and distillery effluents harms the environment and also affects the physical and chemical properties of soil. Hence, vermicomposting is considered a suitable technique for utilizing these organic wastes in high-quality compost with the help of earthworms. More populations of earthworms will be better for more conversion of waste. The use of earthworms will minimize the pollution hazard caused by organic waste degradation. Vermicomposting is the safest method of waste management. Hence, it has been concluded that the different industrial wastes can be utilized as a preferable feed mixture for the growth and reproduction of earthworms. Its primary goal is the recycling of various wastes to create new, economically viable, and agriculturally valuable products.

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