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Physical parameters evaluation during production of soil conditioner from aquatic waste: *Hydrilla verticillata* (L.f.) Royle

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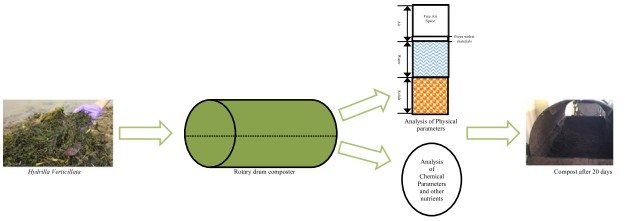
HIGHLIGHTS

- *H. verticillata* is found as a suitable material for composting.
- The addition of cow dung and sawdust aid in efficient composting process.
- Physical parameters evaluated for 20 days during the process.
- Free air space and bulk density is positively correlated.
- Free air space and moisture content exhibited linear correlation.

GRAPHICAL ABSTRACT



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ABSTRACT

Over the decades, composting is a superlative technology to manage organic wastes such as vegetable wastes, sewage sludge, industrial wastes, and aquatic weeds as a soil conditioner. This study focuses on the use of *hydrilla verticillata* as a substrate material, mixed with cow dung, and sawdust. The combined addition of cow dung and sawdust improved the conditions of the composting process and the quality of compost. Along with, conventional parameters such as volatile solids, pH, total nitrogen, and stability parameters this study also describes the proper understanding of process fundamentals about few important physical parameters such as bulk density, particle density, free air space, and moisture content. These parameters were studied during composting of highly invasive aquatic weed (*H. verticillata*) in 550 L rotary drum composter. Thermophilic phase (>45 °C) was reached within 24 h of feeding; volume reduction was clearly depicted as, bulk density also increased from 171 to 761 kg m^{-3} during 20 days composting process. However, the study reveals that particle density of compost varied from 1079.1 to 2313 kg m^{-3} during composting. Proficient compost production involves detailed understanding the process dynamics of correlation between moisture reductions, free air space, bulk density, and

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particle density. Few physical properties during composting of *H. verticillata* are compared with other aquatic weeds reported in literature.

1. Introduction

Aquatic weeds are the most abundant generator of biomass in aquatic bodies. These weeds can be a source of food for some aquatic organism as it is rich in various nutrients such as nitrogen, phosphorus, and potassium. The earlier study stated that weeds such as *Eichhornia crassipes* (water hyacinth), Hydrilla Verticillata (L.f.) Royle (waterthyme), *Pistia stratiotes* (Family: Araceae) and *Salvinia auriculata*, as the most troublesome and considered as aquatic waste (USDA, 2012). An increase in growth of weeds is an indication that aquatic bodies are suffering from severe pollution issue and difficult to solve the problem of an overload of nutrient material (Abbasi, 1997; Khan and Mohammad, 2014; Jain and Kalamdhad, 2018). Moreover, it causes detrimental effects on an aquatic body such as an obstruction in navigation channels, fish production, and also contributes to spreading of disease vectors (Pereira et al., 2012).

Soil conditioner is an end product acquired after the degradation of organic matter by microorganisms under controlled conditions (composting) into a stable product. It is then applied to soil to improve its physical qualities as well as mechanics of soil. Composting has been introduced as one of the effective ways to manage and utilize aquatic weeds (Singh et al., 2012; Singh and Kalamdhad, 2012a, 2013a). It has shown best results, besides being less problematical to fauna than other methods, such as chemical or biological control methods, which can alter structural or chemical properties of aquatic bodies. Therefore, the composting of such aquatic weeds can provide a nutritious end product, which will be utilized for agricultural purpose in the form of soil conditioner (Jain and Kalamdhad, 2018).

Composting is the biological decomposition and stabilization of organic substrates. It occurs under the condition that allows development of thermophilic temperatures (between 40 to 70 °C) as result of biologically produced heat, to produce an end product that is bio stable, free from pathogens and plant seeds, and can be applied on land (Haug, 1993). Composting strongly depends on temperature. This exothermic process produces a large quantity of energy out of which 40%–50% can be utilized by microorganisms to synthesize ATP and remaining energy lost as heat in mass. This heat causes an increase in temperature in mass. Another important parameter during composting is moisture content. Kalamdhad and Kazmi (2009) and Varma and Kalamdhad (2014) reported 50%–65% moisture content as optimum whereas therein is controversy about range; as the moisture content of end product is solely depending on the type of substrate. For the survival of essential microorganism, aeration supply is must during composting to maintain the aerobic condition that can be achieved in many ways, which in turn depend on technology to be used. Composting involves hereupon-chemical reaction (Tchobanoglous et al., 1993):

$$\text{Organic materials} + O_2 + \text{nutrients} \rightarrow \text{New cells} + \text{Energy} + CO_2 + H_2O + \text{product (compost)} + NH_3$$

From above reaction, it is clear to provide aeration system to remove excess carbon dioxide, excess moisture and to inhibit heat accumulation. Degradation process involves changing in properties of organic materials, which in turn changes, as therein is fluctuation in other properties. Also, decomposition process causes to change in volume as well as the weight of material that lowers bulk density and thus limits microbial activity.

Composting not only influences physico-chemical or biological properties during the decomposition process, furthermore, it also reduces the concentration of heavy metals. Leaching of heavy metals is of more concern during composting of aquatic wastes as heavy metal assimilates in the weed through the contaminated water (Singh and Kalamdhad, 2012b). Overviews of the various heavy metal (Zn, Cu, Ni, Cr, Cd, Pb, Fe, Mn) reduction techniques from the composting of different wastes have also been reported in studies (Singh and Kalamdhad, 2013a, b, c; Singh et al., 2013). Several composting studies have been carried out on various substrates such as water hyacinth, vegetable wastes, cattle manure, poultry manure. These studies explained the stability of end product about biological parameters such as oxygen uptake rate (OUR) and carbon dioxide (CO_2) evolution rate and quality about physico-chemical properties such as moisture content, volatile solids, C/N ratio and heavy metals (Kalamdhad and Kazmi, 2009; Ali et al., 2012, Singh and Kalamdhad, 2013a; Nayak and Kalamdhad, 2014). However, very few studies investigated the changes in physical properties during composting process (Ginkel et al., 1999; Mohee and Mudhoo, 2005; Huerta-Pujol et al., 2010; Zhang and Sun, 2016). It is thus, essential to understanding the decomposition process, raw waste materials properties involved, and parameters, which enlightened change in product superiority and magnitude. Physical properties such as moisture content, bulk density, porosity, free air space and various mechanical properties influence directly in the process and product in many ways and play a significant role in the handling and utilization of the product. A study conducted by Agnew and Leonard (2003) stated about the influence of physical properties of compost on the production and use of compost as a soil conditioner.

The study herein paper aims to understand the change in physical properties or composting physics and its correlation with each other during the production of soil conditioner using composting process from an invasive aquatic weed *H. verticillata*, that is submerged, perennial and vascular aquatic plant found in freshwater habitats and found problematic in many parts of the world. Moreover, this paper provides the correlation between various physical parameters and also compares few physical parameters of different aquatic weeds treated using rotary drum composter reported in the literature.