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Short comunication

Vermitechnology: A tool to access and manage the toxicity of fly ash

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Abstract

Fly ash(FA) is pulverized and burnt product of coal which is critical and toxic ceramic material for an environment. It contains various heavy metals which were harmful for soil health ultimately being a major reason for causing various ailments in humans.. The toxic effects of fly ash was seen on the different parameters of earthworms (Eisenia fetida) at higher concentrations. The physico-chemical properties and heavy metals analysis were done at the higher concentrations (50, 75 and100) of fly ash samples. It was found that pH and EC was very high at FA100. TOC was very high and TKN content was found very low at pure samples of fly ash (FA100). Heavy metals content was also high and almost cross the permissible limits at all concentrations. Thus, it was confirmed the localization of fly ash is hazardous to animals as well as the humans.

Keywords: vermicomopsting; Eisenia fetida; fly ash; toxicity.

Introduction

In India the major portion of electricity generation is totally dependent on coal based thermal plants [1]. It was found that the annual production of fly ash is 225 million tonnes per year in 2017 [2]. Fly ash is a fine minute particles (0.5 to 300 micron) produced by burning of pulverised coal in thermal power plant. As being very small sized and light weight, particles can easily pollute the environment [3]. The poor management and disposal of fly ash may cause many ailments like cancer and various types of skin diseases. The slurry of fly ash has a potential to make growth medium for various bacterial and mosquitoes cultures, if it is not properly sorted and managed [6]. It is reported that the fly ash contains some traces of harmful heavy metals which may contaminate the underground water if it is accidently come in contact with stream and other water bodies [7][5]. But now days, government had released many notifications and guidelines about fly ash management as to prevent the random dumping, bad disposal and ill management of fly ash [4]. It has been notified that all the thermal power plants which are engaged to coal have to submit the fly ash (as the waste generate of coal) to cementic and brick making agencies for making low cost cements and bricks. But an important and cautious aspect about mishandling of fly ash by many workers still

needs attention for their health status. It was also observed that the pure form of fly ash (100%) interferers in the growth of earthworms [15]. So the objectives of this study is to reveal the unstable nature of fly ash by studying the physico-chemical properties of it and its effects on the environment. The main objective of this study is to reveal the severe toxicity of fly ash at higher concentration (50, 75 and100%) on soil and earthworms.

Materials and methods

Thermal fly ash was procured from thermal power plant situated in Amritsar, Punjab, India. Fly ash was sieved and clean with the help of sift for removing unwanted particles. Cattle dung was left for 20 days for air drying in order to remove the toxic gases and excess heat from it. The earthworms species (*Eisenia fetida*) were collected from the vermicomposting unit of the Department of Botanical and Environmental Sciences.

Experimental setup

The higher concentrations (50, 75 and100 %) of fly ash feed mixtures was mixed with cattle dung (2kg) in the plastic trays of volume 3,834cc. The whole setup was run in triplicates in vermicomposting unit centre. All the trays were properly covered with hessian cloth and mixture were turned regularly for 15 days. After 15 days, young, healthy and non-clitellated *Eisenia fetida* were selected and collected from the culture and inoculated into the all feed mixtures. The earthworms, cocoon and hatchlings are counted manually after every 15 days. At the end of the experiment (105 days), final product (vermicompost) was air dried, sieved and stored at 10^{o}C (low temperature) for further analysis.

Physico-chemical analysis

The pH and EC (electric conductivity) of all samples were measured in distilled water suspension (1/10 of W/V) with the help of Systronics micro pH system 362 and Systronics conductivity meter-304, respectively. The total organic carbon (TOC), total kjeldahl nitrogen (TKN) were measured with the help of Nelson and Sommer (1996) and microkjeldahl method (2000) respectively. The total available phosphorus (TAP), total sodium and total potassium was measured by the Synergy HT Multi-detection reader and Systronics flame photometer -128 respectively, after digesting sample with diacid mixture ($HClO_4$:HNO_3 in 4:1 ratio). C/N (carbon and nitrogen ratio) was also calculated by using carbon and nitrogen values.

Earthworms growth and mortality:

The total 20 earthworms having total 9 grams (g) of weight were taken and inoculated in each tray of fly ash mixtures. Their number were and weight were counted. According to experiment design, earthworms parameters would have to be counted and measured after 15 days time intervals till end of the vermicomposting. But after observing that the earthworms could not be able to survive in FA100 even for a minute. So, it was decided to count and weight the earthworms daily, in order to study the toxic effects of pure fly ash(FA100) on the earthworms growth.

Results and discussion

In this study, it was found that the higher concentration of fly ash like 50,75 and100% were not be able to convertfly ash into manure through the vermicomposting due to its critical and unstable nature.

Physico-chemical properties

These were performed to reveal the unstable nature of the fly ash mixtures (Table.1). In this study pH and EC of the fly ash mixtures were found to be decreasing from FA50 to FA100. The percentage change in pH (0.67%) and EC were (36.17%) at FA100, drop in pH due to development of anaerobic conditions which may change soil nature by accumulating organic acids in it [8][10]. It is the major reason of un-stability in proton and ions concentration which is very harmful for soil properties.

Table 1: Percent change (%) over initial physico-chemical properties of different proportion of fly ash with cattle dung.

Concentrations	pH	EC(mS/cm)	TOC(%)	TKN(%)	C/N	TNa(%)	TK(%)	TAP(%)
FA0	12.5	79.39	68.69	261.7	82.32	185.22	162.83	156.4
FA50	7.42	50.55	34.58	46.84	54.97	53.97	9.86	95.83
FA75	3.78	42.85	18.88	270.5	39.73	13.02	8.66	89
FA100	0.67	36.17	3.67	177.6	64.80	0.42	3.60	2.18

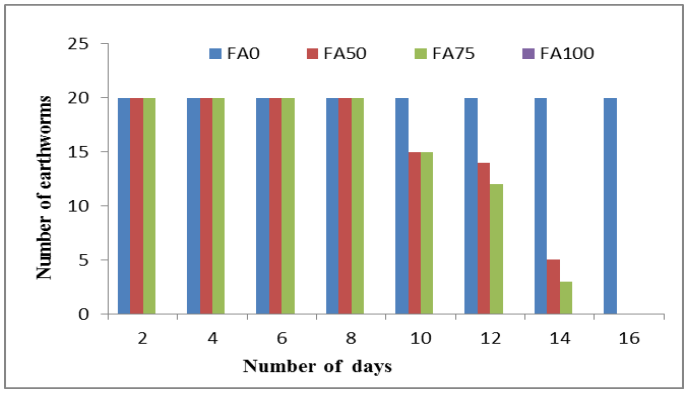
Initial- 0 day and Final-105 days

TOC and TKN of fly ash feed mixtures were measured and found that minimum percent change of TOC at FA100 (3.67%) which can increase the soil alkalinity [9]{11]. On other hand, TKN was showing very low value which cannot be able to support the growth of plant system. At FA 100, minimum percentage change was found to be 177.6% [12]. It was also found that as the higher concentration of the fly ash increased the concentration of carbon compound and decreased the nitrogen content. C/N (carbon and nitrogen ratio) and TNa (total sodium) were studied and found that the C/N ratio increased as the concentration of fly ash increases and the less percent change was seen (64.80%) at FA100, which leads to decomposition of essential compounds like humic acid as it considers good for soil health by playing important role in soil conditioning [13]. Whereas, the TNa content was increased and at high concentration (FA100) low percent change (0.42%) was found which increases the alkalinity in soil and also cause photosynthetic depression in plants by interfering the K+ and Ca2+ ions and ultimately disturbs the stomatal regulation [14]. TK (total potassium) and TAP (total available phosphate) were measured and percentage change was decreased at FA100 by 3.60% and 2.18% respectively. The high concentration of potassium (K) can cause calcium(Ca) and magnesium (Mg) deficiency in soil by interfering in their uptake from the soil and high level of Phosphorus (P) can cause eutrophication [16][17].

Earthworms growth and mortality

The unstable and abnormal results of all the physicochemical parameters reveals that higher concentration of fly ash have allowed the growth and survival of earthworms. The mortality of the earthworm was increased as the concentration of fly ash increase. In FA50, the number of earthworms were remain same (20±0) for 1-10 days and total weight were decreased from 9±0.12g to 6±0.01g. On 11th day, their number were decreased from 20±0 to 16±0.03 with weight loss 6±0.03g to 4±0.01g. It was further seen in consequent days 12,13,14,15 and 16, the number of earthworms were found to be decrease 14±0.02, 10±0.01, 5±0.03, 2±0.02 and 0 with weights (4±0.02g, 3±0.03g, 3±0.01g, 2±0.01g and 0 respectively).

On other hand in FA75,the number of earthworms were decreased from 20±0 to15±0.02 in 1-10 days and total weight were also decreased from 9±0.12g to 4±0.01g. Afterwards, On 11th day, their number were decreased from 15±0.01 to 14±0.04 with weight loss 4±0.02 g to 3±0.01 g. It was further seen in consequent days 12,13,14,15 and 16, the number of earthworms were found to be decrease 14±0.01, 10±0.02, 5±0.01, 2±0.01 and 0 with weights (3±0.02g, 2.2±0.03g, 2±0.01g, 1.1±0.01g and 0 respectively(figure 1).



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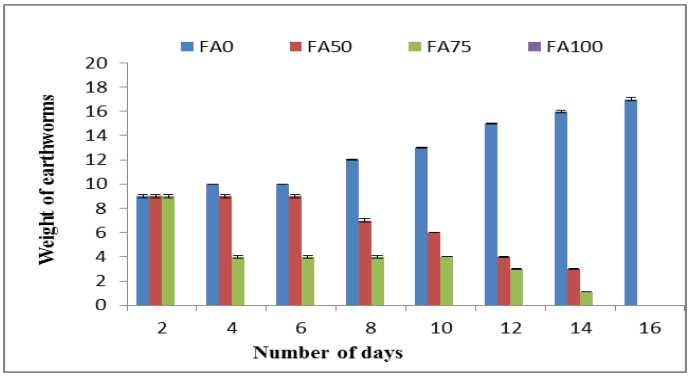

B

Figure 1: Effects of higher concentration of fly ash on number (A) and weight of earthworms (B) at different days during vermicomposting.

Conclusion

The unmanageable fly ash is the major cause of various environmental problems. This study revealed the toxic nature of fly ash. As it bounced the mortality of the earthworms during vermicomposting in high concentration of flyash and found deleterious to the microfauna of the soil. In this way, it can be said that the fly ash is also harmful for other soil microorganisms also. From above study, it can be concluded that the exposure of heavy dose of fly ash is not only harmful for environment but also deleterious to its biotic factors like man and plants ,which are totally dependent on the environment. So the use of pure form of fly ash (FA100) without vermicomposting is inappropriate for cementic and farming purposes.

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Conflict of interest

Authors declares no conflict of interest

Compliance with Ethical Standards

The authors declare that they have no conflict of interest. This article does not contain any studies involving animals or human participants performed by any of the authors

Author Contribution:

B performed the experimental work, prepared the manuscript and also performed the data analysis. SS and JS helped in drafting the manuscript and also helped in data analysis. APV approved the final version of the manuscript.

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