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RESEARCH ARTICLE

Conversion of organic biomedical waste into value added product using green approach

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Abstract
Sustainable organic biomedical waste management is a difficult challenge as this has become one of the serious hazardous wastes. Improper disposal of organic biomedical waste can lead to direct and indirect transmission of diseases. In the present research, the organic biomedical waste samples (32 g blood swabs, 12 g dressing swabs, and 6 g used cotton) were treated with *Azadirachta indica* ("Neem") and *Nicotiana tabacum* ("Tobacco") extracts at various concentrations and kept for 96-h degradation, followed by evaluation of physicochemical parameters. The physicochemical results of organic biomedical waste like pH of the experimental sets were within the optimum range and there was 63.33% of decrease of TDS, 86.15% and 95.30% reduction of BOD and COD, respectively was observed at the end of 96 h. The residues were mixed with 1000 g soil to confirm their role as a potential fertilizer. The physicochemical parameters of soil sample $\mathbf{F_6}$ (neem+tobacco) show an excellent result among all. The phytochemical parameters of a plant were also enhanced as compared to control. The soil samples and the tomato plants were also not polluted by the heavy metals, they are within the limit given by WHO. The present study deals with the conversion of organic biomedical waste into potential fertilizer by using plant extracts which can purely be financially profitable to the farmer.

Keywords Biomedical waste · Total dissolved solids · Chemical oxygen demand · Dissolved oxygen · Electric conductivity · Distilled water · *Azadirachta indica* · *Nicotiana tabacum*

Introduction

Organic biomedical waste is defined as the waste generated during the diagnosis, treatment, or immunization of human beings, animals, or research activities. If biomedical waste not treated properly, it can cause serious environmental problems and health hazards (Anitha and Jayaaj 2012). The biomedical waste invites insects, flies, rodents, dogs, and cats that are liable for the spread of infectious diseases (Kotasthane et al. 2017). Contact with contaminated materials and exposure to infected body fluids while handling biomedical waste have a high risk of blood-borne infections (Jacob et al. 2017). The total generation of biomedical waste by the hospitals in India is about 397 kg/day. Indian cities generate 0.115 million metric tons of waste per day and 42 million metric tons annually (Narang et al. 2012). Most of the hospitals in India include traditional methods; herbal medicines are used for patient's treatment (Peltzer et al. 2016). Approximately 10–25% of biomedical waste is hazardous and infectious while 75–90% of biomedical waste is non-hazardous; if these two wastes were mixed, then whole waste becomes hazardous and infectious waste (Deb et al. 2017).

Incineration is used as most current method for disposal of biomedical waste (Vasistha et al. 2017 and Ghanimeh et al. 2012). Incineration leads to huge amount of air pollution and exposure to harmful gasses like polychlorinated dibenzofurans and polychlorinated dibenzo p-dioxins that damage reproductive system, and also cause the respiratory diseases, hormonal imbalance, and cancer (Prakash et al. 2017). In cities, the organic biomedical waste is disposed of in open dumps. Due to open dumping, there is a risk of soil and groundwater contamination, as well as a decline in air quality (Ali and Yasmin 2014), (Mor et al. 2006).

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Mismanagement of biomedical waste affects the whole society and negative environmental impacts are observed (Ramesh Babu et al. 2009). The organic biomedical waste may be disposed of in the open and mixed with municipal solid waste and disposed at dumping sites near the city which also affects living beings (Gupta and Boojh 2006). Hence, there is a need to improve work safety, collection, transport, handling, and management of biomedical waste (Chaudhuri et al. 2017).

Hence, the focus of present research is to treat organic biomedical waste using an eco-friendly method as the existing method causes a huge amount of pollution and also disturbs the ecosystem of an environment. Analysis of physico chemical parameters of experimental sets was done to evaluate the performance of neem and tobacco extract. Physico-chemical parameters of soil were also analyzed so as to confirm the role as a potential fertilizer. Contamination of heavy metals in soil and plants may pose hazards and risks to living organisms and to the environment so the analysis of heavy metal in plant and soil was also studied.

The detail of this is work highlighted by a schematic diagram in Fig. 1.

Materials and methods

Recently, green approach for biomedical waste management was tried by few authors by giving treatment of *Periconiella* species of fungus isolated from cow dung which shows excellent degradation of organic biomedical waste (Pandey et al. 2011). Rajakannan et al. have used herbal extracts for decomposition of organic biomedical waste but the study was restricted to decomposition and further parameters were not studied (Rajakannan et al. 2013). Looking toward the eco-friendly and organic approach, we have developed an innovative method for degradation of organic biomedical waste by using the extract of herbal Neem and Tobacco. The experiment sets were prepared and kept for degradation for the specified time interval. After degradation of organic biomedical waste, equal proportions of residues were mixed with soil and physicochemical chemical parameters of soil were studied to confirm the role as a potential fertilizer. The phytochemical parameters of plants were studied and it was revealed that the organic biomedical was converted into potential fertilizer.

This study has been approved by the Institutional Ethical Committee (IEC), D. Y. Patil University, Kolhapur.

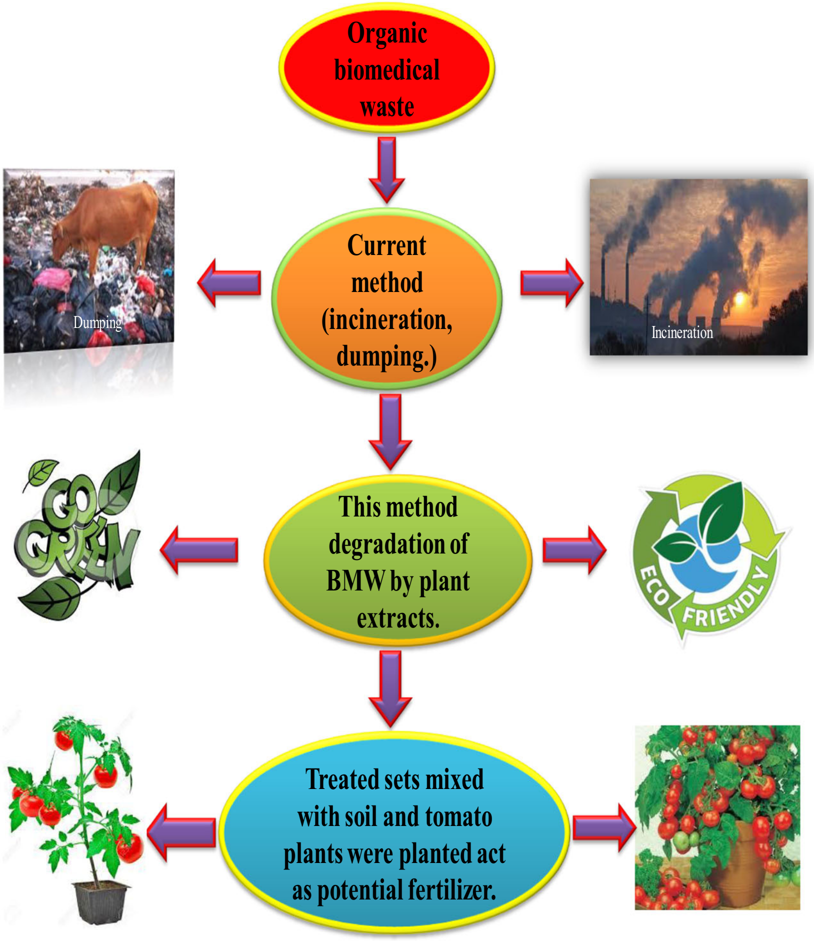

Fig. 1 Graphical representation of the degradation of organic biomedical waste by plant extracts used as potential fertilizer

Collection of samples (for each set)

The 50 g of organic biomedical waste samples (32 g blood swabs, 12 g dressing swabs, and 6 g used cotton) were collected from D. Y. Patil Medical College Hospital and Research Institute, Kolhapur. The biomedical sets are autoclaved at 121 °C for 2 h which are in the form of solid state and prior to use. The sets of an experiment are shown in Table 1 and Fig. 2.

Preparation of neem and tobacco extract

Forty grams of two *Nicotiana tabacum* (Tobacco) leaves which are 45–60 cm long are collected, washed, and dried and followed by 30 ml of d/w addition and then grounded with mortar and pestle and from that 70 ml of extract was collected and in the same way 40 g of 85 to 90 *Azadirachta indica* (Neem) leaves which are 25–40 cm long are collected and 30 ml of d/w was added and ground with mortar and pestle and from that 70 ml of the extract was collected.

Preparation of experimental sets

After collection of a sample, the experimental sets were prepared and kept in airtight containers for 96 h anaerobic degradation.

Mixing of experimental sets into soil

After degradation, the 35 g of residues were mixed with 1000 g soil to confirm their role as a potential fertilizer as shown in Table 2.

Plant selection for the experiment

The tomato plants of 2-weeks species *S. lycopersium* were selected for plantation because it has a short lifespan.

Physicochemical characterization of sample

The physicochemical parameters of the sample were studied like pH, total dissolved solids (TDS) and chemical oxygen demand (COD).

Fig. 2 Preparation of experimental sets

Physicochemical characterization of soil

The physicochemical characteristics of a soil sample were studied like pH, EC, organic carbon, organic matter, total nitrogen, potassium, calcium, magnesium, water holding capacity, and phosphorus.

Phytochemical analysis of plants

The phytochemical parameters of tomato plants were analyzed like estimation of chlorophyll content, polyphenol content, and protein content.

Results and discussions

Physicochemical parameters of experimental sets

pH

Generally, it has been observed that neutral pH favors the degradation rate of biomedical waste, the key challenge is to maintain the pH in the system because the rate of degradation of organic matter is more superior in the pH controlled system than that of without (Nakasaki et al. 1993).

Table 3 shows that the results of pH of experimental sets were analyzed at different time intervals. As Nakasaki et al. reported that neutral pH value can avoid the retardation of the reaction and at its earlier stage also significantly raise the rate of reaction. This will efficiently avoid the problem of odor

Table 1 Preparation of experimental sets

Sr. no.	Name of set	Composition
1	**A**	(Untreated) 50 g of BMW + 40 ml d/w
1	**B**	Tobacco extract 20 ml + 50 g of BMW + 40 ml d/w
2	**C**	Tobacco extract 25 ml + 50 g of BMW + 40 ml d/w
3	**D**	Neem extract 20 ml + 50 g of BMW + 40 ml d/w
4	**E**	Neem extract 25 ml + 50 g of BMW + 40 ml d/w
5	**F**	Tobacco extract 20 ml + Neem extract 20 ml + 50 g of BMW + 40 ml d/w

d/w distilled water, *BMW* biomedical waste

Table 2 Mixing of experimental sets into soil

Sr. no.	Name of set	Composition
1	$\mathbf{A_1}$	(Control)1000 g of soil
2	$\mathbf{B_2}$	35 g set a mixed with 1000 g of soil
3	$\mathbf{C_3}$	35 g set b mixed with 1000 g of soil
4	$\mathbf{D_4}$	35 g set c mixed with 1000 g of soil
5	$\mathbf{E_5}$	35 g set d mixed with 1000 g of soil
6	$\mathbf{F_6}$	35 g set e mixed with 1000 g of soil

which is caused due to retardation and this will also proficiently shorten the required time (Nakasaki et al. 1993). D. Sivakumar also reported that maximum removal of COD and TDS from the waste occurred at optimum pH 7 (Sivakumar 2013). So under well-controlled conditions, the pH of experimental sets were maintained and it was in the optimum range. There were no significant changes in pH; therefore, the degradation rates of experimental sets were superior.

Total dissolved solids (TDS)

All organic and inorganic substances present in a sample and a micro-granular suspended form were considered TDS. The TDS consists of salts like calcium and sodium chloride and iron sulfates (Kasam et al. 2016). The change in climatic condition; an age of the waste, organic, and inorganic materials in the solid waste; and other properties of solid waste are the chief factors for changing the TDS and COD concentration. TDS of samples were measured by standard gravimetric method by evaporating all the water and considering the known volume of water as the weight of the residue (mg) (Atekwana et al. 2004).

Total dissolved solids (TDS) are the expression used to explain the inorganic salts and minute amount of organic matter in solution. The technique of determining TDS in waste provisions mainly used is the measurement of definite conductivity with a conductivity probe that identifies the occurrence of ions in waste. Conductivity measurements are transformed into TDS values by a factor that varies with the type of waste. The TDS of different sets with the different time interval are shown in Table 4. There is a progressive decrease in TDS except for control at the end of 96 h while in the case of sample f the value of TDS was decreased drastically from 1200 to 330 mg/l; this value is far superior to that of required value for fertilizer.

Chemical oxygen demand (COD)

The total concentration of organic waste present in the sample is estimated by COD and BOD because they are one of the most important parameters in the determination of organic waste present in the sample. If the level of COD is high then the greater amount of oxidizable organic material is present in the sample and that decreases dissolved oxygen (DO) levels (Mata-Alvarez et al. 2000). The most general application of COD is to find out the amount of oxidizable pollutants in water (Khwairakpam and Bhargava 2009). Table 5 shows the COD values of experimental sets at various concentrations (mg/l).

The COD of experimental sets were analyzed at various time intervals; from these results we can conclude that the COD range of samples was more in initial readings and as time increases the COD level decreases. At the end of 96 h, there was a superior decrease in COD in all the samples except control and better results are shown by sample **f** among all. This result shows an important role of presence of tobacco and neem and conversion of organic biomedical waste into potential fertilizer. The reduction of COD from the biomedical waste will help to add the value to the end product. C. Rajakannan et al. reported that after 120 h, 90% of COD has been reduced when biomedical waste was treated with neem extract but further parameters are not studied only, it is restricted up to decomposition (Rajakannan et al. 2013).

Biological oxygen demand (BOD)

To determine the qualified oxygen necessities in waste, effluents, and in contaminated water, biochemical oxygen demand (BOD) is an essential environmental index (Khwairakpam and Bhargava 2009). It determines the molecular oxygen utilized during a specific incubation time for the degradation of organic matter and the oxygen used to oxidize inorganic matter (Mohabansi et al. 2011; Trujillo et al. 2006). The significant aspect of compost quality is recognized by the proportion

Table 3 pH of experimental sets at various time intervals

Sr. no	Name of set	Initial reading	After 48 h	After 96 h	After 168 h
1	**a**	6.6 ± 0.12	6.4 ± 0.22	6.2 ± 0.22	6.2 ± 0.34
2	**b**	6.6 ± 0.42	7.1 ± 0.44	6.7 ± 0.13	6.7 ± 0.22
3	**c**	6.7 ± 0.23	7.2 ± 0.22	7.3 ± 0.35	7.5 ± 0.18
4	**d**	6.7 ± 0.11	7.3 ± 0.35	7.4 ± 0.22	7.3 ± 0.32
5	**e**	6.6 ± 0.23	7.8 ± 0.21	7.2 ± 0.40	7.7 ± 0.24
6	**f**	6.4 ± 0.14	7.3 ± 0.13	7.3 ± 0.21	7.0 ± 0.22

Table 4 TDS (mg/l) of experimental sets at various time intervals

Sr. no	Name of set	Initial reading	After 24 h	After 48 h	After 96 h
1	**a**	1200 ± 1.20	1220 ± 1.24	1200 ± 2.53	1230 ± 1.32
2	**b**	1200 ± 1.35	920 ± 2.46	590 ± 1.35	430 ± 1.54
3	**c**	1200 ± 2.19	830 ± 1.80	480 ± 1.53	390 ± 1.69
4	**d**	1200 ± 1.17	980 ± 2.61	770 ± 1.21	490 ± 2.41
5	**e**	1200 ± 1.48	810 ± 1.32	680 ± 2.53	440 ± 2.55
6	**f**	1200 ± 1.44	770 ± 1.64	490 ± 1.30	330 ± 1.29

of readily biodegradable organic material (Rastogi et al. 2003). After applying compost to the soil for crop use, biological processes will continue, so care should be taken because after stabilization of compost soil nutrients can strip (Kalamdhad 2013) (Table 6).

At different time intervals, the BOD of experimental sets was analyzed. The initial reading of BOD was more, as time increases the BOD level decreases. At the end of 96 h, except control, all the sample shows a significant decrease in BOD while in the case of sample **f** the value of BOD was decreased drastically from 130 to 18 mg/l. This value was far superior to that of the required value for fertilizer.

Physicochemical parameters of the soil sample

Physicochemical parameters of the soil sample such as pH, electrical conductivity (EC), organic carbon, organic matter, phosphorus, potassium, nitrogen, calcium, magnesium, and water holding capacity are essential factors and should present in an optimum range. These parameters play a vital role in the growth and development of plants. The details of each parameter are shown in Table 7. Physiochemical parameters of soil before and after the addition of residues are shown in Tables 8 and 9.

The ranges of pH in the soil should be within the tolerable limit (5.5–9.0) to microorganisms, bacteria and fungi. Most of the crops grow in the neutral range of pH and other parameters of soil also affect the pH range (Steiner et al. 2007). After addition of residues, the A_1 soil has slightly acidic pH whereas other soils have neutral pH value which reduces soil crusting, increases soil microbial activity. Electrical conductivity (EC) of soil is a measurement that correlates the properties of soil which affect the productivity of crop, including of soil, drainage conditions, cation exchange capacity, salinity, organic matter, and sub soil properties (Grisso and Engineer 2009). The A_1 soil has less EC content as compared to other soil and F_6 soil has more content of EC. To assimilate and treat organic wastes, soil has a substantial capacity. Using waste land at agronomic rates for fertilizer and plant nutrient supply has been the waste management by the traditional mean. Applying of solid waste, either for fertilizer or for disposal purpose increases the organic carbon and organic matter content of the soil. An increase in organic carbon and organic matter content of the soil increases water holding capacity, increases aggregation and hydraulic conductivity, and decreases bulk density (Carolina 1981 and Jakobsen 1995). After addition of residues to the soil, the organic matter and organic carbon were enhanced as compared to control and they are in the optimized range. To determine soil water holding capacity, soil organic matter and texture are the key components. The main way to improve water holding capacity is designing of management practices to develop soil structure (Evanylo et al. 2008). Therefore, the addition of residues increases the water holding capacity as well as enhanced all the physico chemical parameters of soil as compared to control. The soil sample $\mathbf{F_6}$ (neem+tobacco) shows an excellent result among all.

The use of waste as mannure is increased due to the rise in the price of conventional ferilizers in the recent year. In the recent year's utilization of waste as manure is becoming widespread, as a consequence of conventional fertilizers rises in price. The well-known problem is of disposal of waste so the agricultural use of waste contributes to minimize waste; however, it is suggested that treatments with moderate doses of waste as a fertilizer can be adequate to maintain superior levels of available potassium and phosphorus content in soils and to improve crop yields (Lynch 2011). In soil, the major source of nitrogen

Table 5 COD (mg/l) of experimental sets at various time intervals

Sr. no.	Name of set	Initial reading	After 24 h	After 48 h	After 96 h
1	**a**	4232 ± 2.02	4241 ± 5.03	4220 ± 3.08	4232 ± 1.01
2	**b**	4232 ± 2.04	3134 ± 3.00	1394 ± 2.01	233 ± 1.74
3	**c**	4232 ± 3.00	2634 ± 2.02	857 ± 1.00	192 ± 1.01
4	**d**	4232 ± 2.12	3310 ± 3.04	1045 ± 2.03	432 ± 1.81
5	**e**	4232 ± 4.06	3106 ± 2.02	927 ± 1.02	319 ± 1.90
6	**f**	4432 ± 5.03	2113 ± 2.03	826 ± 2.04	208 ± 1.03

Table 6 BOD (mg/l) of experimental sets at various time intervals

Sr. no.	Name of set	Initial reading	After 24 h	After 48 h	After 96 h
1	**A**	130 ± 2.12	123 ± 2.12	119 ± 1.10	112 ± 1.51
2	**B**	130 ± 1.10	102 ± 2.12	73 ± 1.10	28 ± 1.10
3	**C**	130 ± 1.09	92 ± 1.10	53 ± 1.09	22 ± 1.09
4	**D**	130 ± 1.15	118 ± 1.09	64 ± 1.15	34 ± 1.15
5	**E**	130 ± 1.32	109 ± 1.15	57 ± 1.32	28 ± 1.32
6	**F**	130 ± 1.22	84 ± 1.32	49 ± 1.22	18 ± 1.22

is atmospheric nitrogen. Ninety-five to 99% nitrogen available in the soil is in organic forms, moreover in animal and plant residues, in the comparatively stable soil organic matter, or in soil microorganisms. The large quantity of nitrogen is required for the growth of a plant and to get better crop yield. Magnesium and calcium have several nutrients which can meet the plant demand. Plants with sufficient calcium and magnesium have a greater number of fruits and it also increases the root growth of the plant. Calcium and magnesium are important in the cell wall and cell membrane stability of fruit (Cole et al. 2016). So after adding the residue, there is a huge difference in all the parameters. The results of nitrogen calcium and magnesium are also enhanced as evaluate to A_1 (control). The soil sample $\mathbf{F_6}$ (neem+tobacco) shows an excellent result among all (Table 10 and 11).

Heavy metals of the soil sample

The biodegradation of organic contaminants can be severely inhibited by the existence of toxic metals in soil (Mihailovic and Gajic 2008). Contamination of heavy

Table 7 Details of physicochemical parameters of the soil

Sr. no.	Name of parameter	Importance of parameter in soil	Reference
1	pH	The pH of soil will have a considerable effect on the biochemical process present in the soil. The pH of soil will affect the chemical form, availability, and concentration of substrate	Nicol et al. (2008)
2	Electrical conductivity (EC)	EC (electrical conductivity) is a measure of the salts present in the soil. EC affects crop suitability and plant nutrient present in the soil	Brevik et al. (2006)
3	Organic carbon	Soil microorganisms are a source of energy of soil organic carbon. Total organic carbon forms are derived from the decomposition of plants and animals. They are able to decompose. They have organic compounds like oxygen, carbon, nitrogen, and hydrogen, therefore bicarbonates, carbonates, and elementary carbon such as graphite are not organic carbon	Six et al. (2002) Edwards et al. 1992 and Holtan et al. 1988
4	Organic matter	Soil organic matter decreases erosion and helps to stabilize soil particles. Organic matter is diverse to organic carbon in that it consists of every element (oxygen, nitrogen, hydrogen, etc.) that are components of organic matter, not just carbon	Six et al. (2002)
5	Phosphorus	Phosphorus is the eleventh rich element available in the earth crust. If there is a lack of phosphorous then there will be reduction in yield and the plant's growth are also stunted	Bennett et al. (2001)
6	Potassium	The availability of potassium range is less, plants accumulate more quantity of this element The accessibility of potassium goes on varying due to complex soil dynamics	Ashley et al. (2006); Sindhu and Comfield (1967)
7	Nitrogen	Most of the nitrogen in the soil is organically bound but a small amount of nitrogen is present in the inorganic form; however, the inorganic form of nitrogen which is available in the soil is directly absorbed by plants	Bodelier and Laanbroek (2004)
8	Calcium	Calcium is an essential nutrient for plant growth. The calcium is called as a secondary nutrient because in smaller quantity plants require calcium. To give structural support to cell walls is the principal function of calcium	Maathuis (2009)
9	Magnesium	Magnesium is also known as a secondary nutrient because in smaller quantity plants require magnesium, but on the other hand, the micronutrient plants require these nutrients in a larger amount	Van Raij et al. (1986)
10	Water holding capacity	To grow mediums ability to hold water is referred to as water holding capacity. The water holding capacity is controlled by the composition, quantity of organic matter, and by its texture	Karhu et al. (2011)

Table 8 Physicochemical parameters of the soil sample

Sr. no	Sample	pH	EC	Organic carbon	Organic matter	Water holding capacity
1	$\mathbf{A_1}$	5.8 ± 0.14	0.58 ± 0.04	7.06 ± 0.18	12.10 ± 1.22	45.23 ± 3.02
2	$\mathbf{B_2}$	7.6 ± 0.13	0.76 ± 0.06	8.10 ± 0.13	15.17 ± 1.03	56.21 ± 4.13
3	$\mathbf{C_3}$	7.8 ± 0.12	0.79 ± 0.09	11.11 ± 0.15	17.18 ± 1.32	67.35 ± 3.22
4	$\mathbf{D_4}$	8.2 ± 0.06	0.63 ± 0.02	13.07 ± 0.13	19.12 ± 1.51	73.44 ± 4.01
5	$\mathbf{E_5}$	7.9 ± 0.08	0.68 ± 0.04	14.09 ± 0.16	23.15 ± 1.02	79.53 ± 2.12
6	$\mathbf{F_6}$	7.6 ± 0.13	0.89 ± 0.06	17.14 ± 0.17	28.24 ± 1.04	87.81 ± 3.13

All values are in percentage. Unit of EC is in μ

Table 9 Physicochemical parameters of the soil sample

Sr. no.	Sample	Potassium	Phosphorus	Total nitrogen	Magnesium	Calcium
1	$\mathbf{A_1}$	0.08 ± 0.01	0.47 ± 0.02	0.12 ± 0.02	0.03 ± 0.02	0.54 ± 0.03
2	$\mathbf{B_2}$	0.22 ± 0.01	0.52 ± 0.03	0.23 ± 0.02	0.13 ± 0.01	0.57 ± 0.01
3	$\mathbf{C_3}$	0.36 ± 0.03	0.61 ± 0.05	0.35 ± 0.04	0.16 ± 0.03	0.64 ± 0.02
4	$\mathbf{D_4}$	0.51 ± 0.02	0.72 ± 0.12	0.44 ± 0.01	0.23 ± 0.04	0.77 ± 0.05
5	$\mathbf{E_5}$	0.73 ± 0.06	0.83 ± 0.06	0.54 ± 0.03	0.33 ± 0.03	0.84 ± 0.02
6	$\mathbf{F_6}$	0.96 ± 0.04	1.02 ± 0.05	0.82 ± 0.02	0.46 ± 0.01	0.92 ± 0.05

All values are in percentage; calcium and magnesium are in mg/lit

metals in soil may pose hazards and risks to living organisms and to the environment by direct intake or through contact with contaminated water, soil, food chain etc. In all living organisms, heavy metals have the multiplicity of biochemical functions and they are essential micronutrients (Wuana and Okieimen 2011; Abdel-daim 2018). Though they are necessary to living organisms, they can be harmful and toxic when they are above the limit and they could also cause pollution when they are beyond the limit; both necessity and toxicity differ from species to species. Knowledge of the basic environment, chemistry, and health effects of heavy metals is required in understanding their bioavailability, speciation, and remedial options (Liu et al. 2013 and Li et al. 2011). Homeostatic mechanisms are possessed by plants which keep the heavy metals in the accurate concentrations in cellular compartments of essential metal ions and minimize the harmful effects of an excess of unnecessary ones (Chibuike and Obiora 2014). The soil samples and tomato plants were analyzed to determine the presence of heavy metals (Mn, manganese; Cd, cadmium; Fe, iron; Ni, nickel; Co, cobalt; Zn, zink; Cu, copper; Cr, chromium). From Table 9, we can conclude that the soil samples and the tomato plants are not polluted by the heavy metals; they are within the limit given by WHO. So there is no risk to living organisms and to the environment as there is no contamination of toxic metals in the soil samples and in the tomato plants.

Phytochemical parameters of (tomato plant)

The tomato plants were grown in treated and non-treated soil to confirm the role as a potential fertilizer. Phenols are derived from secondary plant metabolism of the shikimic acid pathway, malic acid pathway or both

Table 10 Heavy metals of soil

Sr. no.	Sample	Mn	Cd	Fe	Ni	Co	Zn	Cu	Cr
1	$\mathbf{A_1}$	−0.11	0.29	0.73	0.76	0.77	2.34	1.83	−0.23
2	$\mathbf{B_2}$	−0. 30	0.14	0.36	−0.68	0.73	1.25	1.24	−0.32
3	$\mathbf{C_3}$	−0.45	0.15	0.54	−0.65	0.34	1.09	0.83	−0.34
4	$\mathbf{D_4}$	−0.12	0.12	−0.11	−0.43	0.65	1.23	1.04	−0.58
5	$\mathbf{E_5}$	−0.16	0.14	0.12	−0.28	0.81	1.33	0.94	−0.32
6	$\mathbf{F_6}$	−0.53	0.08	0.13	−0.74	0.23	0.43	0.23	−0.61

Table 11 Heavy metals of tomato leaves

Sr. no.	Sample	Mn	Cd	Fe	Ni	Co	Zn	Cu	Cr
1	$\mathbf{A_1}$	− 0.14	0.09	0.79	0.61	0.89	2.31	1.32	− 0.03
2	$\mathbf{B_2}$	− 0.32	0.03	0.41	− 0.57	0.69	1.18	1.34	− 0.09
3	$\mathbf{C_3}$	− 0.39	0.04	0.49	− 0.68	0.44	1.34	0.93	− 0.21
4	$\mathbf{D_4}$	− 0.15	0.05	− 0.13	− 0.47	0.67	1.03	1.64	− 0.56
5	$\mathbf{E_5}$	− 0.18	0.02	0.42	− 0.34	0.79	1.02	0.89	− 0.43
6	$\mathbf{F_6}$	− 0.54	0.03	0.19	− 0.71	0.27	0.59	0.61	− 0.56

phenylalanines are the precursors for phenolic compounds. Phenolics have different functions in plants (Hartmut and Ursula 1988). The proteins are derived from smaller molecules called amino acids. Proteins play a crucial role in the growth and development of plants (Waters et al. 1996). The estimation of protein content was done by Lowry's method. The chlorophyll content of leaf extract was conducted by the standard method reported by sadasivam and manickam, and by Folin–Ciocalteu procedure total polyphenols were determined (Xu et al. 2006). From Table 10, let us conclude that the plant F_6 has higher chlorophyll contents than that of other plants. So it indicates tomato plant F_6 was healthier than other plants. There was maximum polyphenol content in sample $\mathbf{F_6}$ (neem+tobacco) followed that of *Azadirachta indica* (Neem). This indicates that the plant $\mathbf{F_6}$ has more protein and amino acid content. Similarly, the growth and development were also good.

Morphological parameters of tomato plant

Plant height: (Tomato plant)—Plant $\mathbf{F_6}$ has the highest plant growth than that of other plants. Required nutrients for plant growth were provided by experimental sample **f** (neem+tobacco). The EC, organic carbon, organic matter, potassium, phosphorus, nitrogen, calcium, and magnesium of soil sample $\mathbf{F_6}$ were high. The F_6 (neem+tobacco) tomato plant has high chlorophyll, polyphenol, and protein content followed by individual tobacco (c, b) and individual neem (e, f). Hence, the highest plant growth was seen in sample **f**. The results are shown in Table 12.

Mechanisms of action

The existences of polyphenol content in herbal extracts are responsible for degradation of any organic matter present in the waste sample. Huge research is approved out on extensive range of herbal extracts and its chemical components. The polyphenol content is used as a green approach for biodegradation and for treatment purpose (Devatha et al. 2018). Herbal extracts were preferred based on the existence of polyphenols, neem shows 82.35% reduction of chemical oxygen demand. Neem shows the satisfactory reduction of organic matter present in waste samples as compared to other herbal extracts. On the 11th day, there is a huge reduction in COD of the waste sample due to polyphenol content in leaf extracts (Table 13). The study proved that the exploitation of herbal extracts for the degradation of organic waste is an agreeable, cost-effective, and ecofriendly method (Devatha et al. 2016). The treatment of herbal extract is a natural and traditional method available. It has been reported that neem and tobacco extract shows antifungal, antibacterial, and antiviral, activites due to existences of polyphenols content (Ravva and Korn 2015).

Table 12 Phytochemical parameters of (tomato plant)

Sr. no.	Sample	Chlorophyll (mg/100 g)	Polyphenol (mg/1000 g)	Protein (mg/g)
1	$\mathbf{A_1}$	103.72 ± 1.01	19,600 ± 7.01	0.37 ± 0.07
2	$\mathbf{B_2}$	165.40 ± 1.43	46,000 ± 6.01	1.25 ± 0.05
3	$\mathbf{C_3}$	184.31 ± 3.95	44,800 ± 7.04	1.38 ± 0.06
4	$\mathbf{D_4}$	118.54 ± 2.70	28,400 ± 8.00	0.86 ± 0.00
5	$\mathbf{E_5}$	123.45 ± 1.62	24,500 ± 5.03	1.18 ± 0.02
6	$\mathbf{F_6}$	225.55 ± 1.04	52,000 ± 5.04	1.45 ± 0.01
7	Neem extract	156.23 ± 0.84	32,000 ± 6.14	1.96 ± 0.03
8	Tobacco extract	283.47 ± 0.96	54,000 ± 8.04	2.01 ± 0.05

Table 13 Height of the plants

Sr. no.	Treatment	20 days	40 days	60 days
1	A_1	12 ± 1.08	26 ± 0.13	39 ± 0.21
2	B_2	31 ± 0.14	42 ± 0.09	54 ± 0.14
3	$\mathbf{C_3}$	34 ± 1.12	53 ± 0.12	67 ± 0.33
4	$\mathbf{D_4}$	19 ± 0.18	26 ± 1.14	42 ± 1.13
5	$\mathbf{E_5}$	26 ± 0.03	41 ± 0.24	52 ± 1.21
6	$\mathbf{F_6}$	43 ± 1.09	68 ± 1.13	92 ± 1.13

Conclusion

The present research proves conversion of organic biomedical waste into potential fertilizer by using the extracts of neem and tobacco and which can be turned financially profitable to a farmer as neem and tobacco extracts show excellent results in degradation of organic biomedical waste. 63.33% decrease of TDS, and 86.15% and 95.30% reduction of BOD and COD, respectively were observed at the end of 96 h. The physicochemical and phytochemical parameters of soil and plant are also enhanced as compared to control. The soil samples and the tomato plants are also not polluted by the heavy metals. They are within the limit given by WHO so the final treated waste is good source of fertilizer as there is no risk to living organisms and to the environment as there is no contamination of toxic metals in the soil samples and in the tomato plants. So the use of plant extracts for conversion of organic biomedical waste into potential fertilizer on the basis of nutrient content is imperative indication that this method will reduce a load of synthetic fertilizer.

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