Study of plant nutrients availability of raw and treated press mud of different sugar mill industries for organic agriculture

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Abstract:

This study has been undertaken to investigate the Physico-chemical properties and plant micro/macro nutrients availability of raw press mud (RPM) and treated press mud (TPM) samples by Energy Dispersive X-ray Fluorescence (ED-XRF) analysis. RPM and TPM samples were found to be composed of plant nutrients like organic carbon, nitrogen, sulphur, chlorine, nickel, copper, zinc, selenium, bromine, strontium, molybdenum, tin, antimony, barium and oxides of SiO_2, Al_2O_3, K_2O, CaO, MgO, P_2O_5, MnO, Fe_2O_3. Raw press mud and treated press mud is observed to possess different elemental composition. The micro/macro nutrients and trace elements content are in higher level in TPM due to spraying of distillery spent wash on it The present study focuses on the need of understanding the composition or nutrient availability status of press mud for eco-friendly, healthy and sustainable organic agriculture practice.

Key words: Raw press mud, treated press mud, plant nutrient availability, ED-XRF

1. Introduction

Press mud is ever ignored waste byproduct released from sugar industries which contain plant nutrients, thus can be converted into rich organic manure besides improving the soil fertility and minimize industrial solid waste (Rakkiyappan P. Thangavelu S. et.al 2001). Press mud is discarded or returned to the fields as fertilizer with little processing (Yadav D.V.1992). It can provide alternative fertilizer which can replace chemical fertilizer to a good extent (Bokhtiar S. Sakurai 2005). In a country like India which have many numbers of sugar industries, press mud can be a good fertilizer for organic agriculture. Most of sugar industries allied with distillery unit adopting common practice of spraying of distillery spent wash on press mud for the purpose of plant nutrient enrichment. Sugar cane by-product press mud is composted into a very nourishing organic manure, biodegraded into compost product which is used in agricultural field as the fertilizing agent. It contains rich in micro and macro nutrients with organic carbon or soil conditioner along with it rises the useful microbial population, improve microbiological standard and can produce important enzymes (Sunil Kumar, R S Meena, et al 2017). By-products of sugar industry press mud is recycled through agriculture due presence of availability of plant nutrients in it. Application of press mud nourishes soil with elements like N, P, K, Fe, Zn, Mn, and Cu, thereby increasing crop yield, crop quality with reduced use of chemical fertilizers. Using inorganic fertilizer along with press mud as commercial fertilizer for a particular cropping system (M. L. Dotaniya, S. C. Datta, D. R. Biswas, et al 2016) is also suggested. Modification of sugar press mud into economically viable production of biogas, bioethanol, biodiesel, bio-manure, bleaching agent (Karan M. Agrawal, B. R. Barve, et al 2010, Pedro Dionisio Remedios Castaneiras et al 2019, Kumar, S., Meena, R.S., Jinger, D.et al 2017) is also demonstrated.

Raw press mud: Press mud contains macronutrient; micronutrients and trace elements which gets absorbed through plant's roots enhancing plant growth. It contains moisture, sugar, fiber, coagulated colloids, wax, albuminoids, organic salts, organic carbon, N, P, Ca, Fe and Mn (Rouf, M.A., P.K. Bajpai and C.K. Jotshi, 2010).

Treated press mud: Composting of press mud is called as 'treated press mud'. Treated press mud is enrichment of plant nutrients viz: N, P, K, Mg, Ca, Zn, Cu, Fe and Mn (Baskaran et al. 2009; Kumar et al. 2017). It is a source of plant macro/micro nutrients, organic fertilizer, soil enrich source for crops. Treated press mud has useful organic matter and is enriched with microbes like Trichoderma sp. It is used as biofertilizer for improving the soil fertility, agronomic productivity and reduce the use of chemical fertilizers. The major use that has been developed in India as making bio-compost named as bio-earth treated with the spent wash from the distillery. The bio-compost is produced by spraying spent wash on stacks of press mud called windrows and the time required to produce usable fertilizer varies with the process, typically about 45-days.

2. Material and Methods

After completion of sugar crushing season, immediately filed campaign is carried out and dried in sunlight to remove the moisture and odor. The dried press mud samples were sieve in the size range of 0.6 um sieve stored in airtight plastic containers for analyses. Total 4 cooperative sugar industries mills in Maharashtra, India was selected for present study, out of which two sugar industries are from Pune district. The chosen sugar industries are as below:

1)Malegaon Sugar Mill, Pune district -RPM1, TPM1

2) Someshwar Sugar Mill, Pune- RPM2, TPM2

3) Saswad-mali nagar Sugar Mill, Solapur district- RPM3, TPM3

4) Pandurang Sugar Mill, Solapur district- RPM4, TPM4

Energy Dispersive X-ray Fluorescence (ED-XRF)

Instrument -Spectra XEPOS MTECK, Elemental composition of raw and treated press mud was carried out by using instrument ED-XRF.

3.Results and Discussion:

1) Organoleptic and physical parameters

Colour of raw press mud was dark brown and treated press mud was black and dark brown colour. Odour of raw and treated press mud was unpleasant smell.

2) Physico-chemical analysis of RPM and TPM

The physico-chemical parameters were analyzed like pH, E.C., Organic carbon.

Variation of pH, E.C, Organic carbon in RPM and TPM:

pH value at optimal and neutral range 6 to 7. pH value of treated press mud samples varied and slightly increased pH value 7.66 to 9.16, alkaline range indicate presence of excessive amounts of soluble salts. Electrical conductivity of raw and treated press mud samples comparatively studied and showed that, lower EC values observed in RPM than TPM. Higher EC shows free ion availability in TPM and vice versa. Organic carbon content of all samples of RPM and TPM were same either 0.5 % to 0.75 % or 0.75 %.

3) Energy Dispersive X-ray Fluorescence (ED-XRF)

Result of ED-XRF elemental composition explained on the basis of plant nutrients.

I) Primary macronutrients: Variation of Nitrogen as N (N %), Phosphorus (P %), Potassium (K %) in RPM and TPM

The macronutrients, N, P, and K, are used in large quantities by plants called as major or ‘primary’ macronutrients, because their deficiencies of N, P, and K are more common. Nitrogen content in raw press mud samples was observed, RPM1, RPM2, RPM3, RPM4 in % (2.21, 3.45, 3.42, 2.62) respectively. The increasing order of raw press mud samples were RPM2 > RPM3 > RPM4 > RPM1.The nitrogen content in treated press mud samples was observed, TPM1, TPM2, TPM3, TPM4 in % (1.01, 2.42, 2.01, 1.35) respectively. Results of raw and treated press mud samples comparatively studied that; the higher nitrogen content observed in raw press mud samples as compared to treated press mud. Phosphorous content in RPM1 (4.40 %) increased in TPM1 (5.4 %), RPM2 (3.199 %) increased in TPM2 (3.91 %), RPM3 (2.895 %) increased in TPM3 (3.542 %), but in RPM4 (5.856 %) decreased in TPM4 (4.675 %). Higher phosphorous content observed in treated press mud samples as compared to raw press mud, except TPM4 as compared to raw press mud. The potassium content in RPM1 (0.3303 %) increased in TPM1 (2.75 %), RPM2 (2.129 %) increased in TPM2 (2.562 %), RPM3 (0.6316 %) increased in TPM3 (3.518 %) and RPM4 (2.548 %) increased in TPM4 (4.538 %). Potassium content increased in treated press mud sample as compared to raw press mud sample.

II) Secondary macronutrients : Variation of Calcium (Ca%), Magnesium (Mg %), and Sulphur (S ppm) in RPM and TPM

Calcium (Ca), magnesium (Mg), sulphur (S) are required smaller or appreciable quantities called as ‘secondary’ macronutrients. The calcium content in RPM1 (7.738 %) increased in TPM1 (10.88 %), RPM2 (9.723 %) increased in TPM2 (12.72 %), RPM3 (6.593 %) increased in TPM3 (8.453 %), but RPM4 (12.58 %) decreased in TPM4 (10.46 %). Magnesium content in raw press mud samples was observed, RPM1, RPM2, RPM3, RPM4 (0.795 %, 3.27 %, 0.773 %, 2.681 %) respectively. The calcium content in treated press mud samples was observed TPM1, TPM2, TPM3, TPM4 (1.64 %, 1.998 %, 1.366 %, 2.298 %) respectively. Result of raw and treated press mud samples comparatively studied that; calcium content increased in treated press mud sample as compared to raw press mud sample except TPM4 sample. Magnesium and Sulphur content increased in treated press mud sample as compared to raw press mud sample.

III) Micronutrients or trace elements:

Micronutrients are those elements essential for plant growth which are needed in only very small (micro) quantities, so called as minor elements or trace elements (Broyer T. and Stout P. 2010). In soils, occurring in high amounts of these micro elements may also toxic to plants and it’s in development of plant growth.

Variation of Silicon (Si), Aluminium (Al), Manganese (Mn), Iron (Fe):

The Si content in RPM1, RPM2, RPM3, RPM4 in percentage (5.123, 5.784, 5.747, 5.868) and TPM1, TPM2, TPM3, TPM4 in percentage (7.109, 13.14, 25.69, 6.385) respectively. Al content in RPM1, RPM2, RPM3, RPM4 in percentage (0.3643, 0.3518, 0.4016, 0.4852) and TPM1, TPM2, TPM3, TPM4 in percentage (0.4282, 0.857, 2.92, 0.429) respectively. Manganese content in RPM1, RPM2, RPM3, RPM4 in percentage (0.06389, 0.05596, 0.05117, 0.05518) and TPM1, TPM2, TPM3, TPM4 in percentage (0.07885, 0.06716, 0.05898, 0.04754) respectively. Iron content in RPM1, RPM2, RPM3, RPM4 in percentage (0.6698, 0.7966, 0.8845, 1.014) and TPM1, TPM2, TPM3, TPM4 in percentage (0.7839, 1.518, 0.85, 0.9184) respectively. Si content increased in all treated press mud sample and Al and Mn content increased in treated press mud sample, except TPM4. Iron content increased in treated press mud sample TPM1, TPM2 but decreased in TPM3, TPM4.

Variation of Chlorine (Cl), Nickel (Ni), Copper (Cu), Zinc (Zn), Selenium (Se), Bromine (Br), Strontium (Sr), Molybdenum (Mo), Tin (Sn), Antimony (Sb), Barium (Ba), Lead (Pb)

Result of raw and treated press mud samples comparatively studied and it observed that, ppm of Cl, Ni, Zn, Se, Br, Sr, Mo, and Sn content increased in all treated press mud sample. Cu content change and increased in treated press mud sample TPM3 and TPM4 and decreased in TPM1 and TPM2. Sb content in the RPM2, RPM4 indicated 0 ppm, but it increased in TPM2, TPM4. Ba content increased in treated press mud samples, except TPM2. Pb content in RPM1, RPM2, RPM3, RPM4 in ppm (3.4, 7.9, 5.1, 6.9) and TPM1, TPM2, TPM3, TPM4 in ppm (4.4, 11.6, 17.0, 7.0) respectively. Pb increased in all treated press mud sample but, it is in minor amounts, so no possibilities of 'lead poisoning' of plants after using it as a fertilizer.

Earlier studies suggests that, press mud can be used as organic fertilizer which in rich in micro/macro plant nutrients and thus reducing the usage of chemical fertilizers. Press mud prevents disease-causing fungi and useful for soil in enriching in the total content of N, P, K. It can provide alternative easily available, low cost, organic fertilizer which can replace chemical fertilizer. Press mud is fertilizing agent, also vermicompost's using press mud increase plant nutrients. Press mud increases the moisture, micro and macro nutrient of the soil which are beneficial for agriculture. Press mud as an eco-friendly and healthy manure for crops as well as for agriculture practices. The press mud has to be stored in large open areas and large lagoons are to be set up to store the spent wash so the long-term effects of application of this fertilizer remain. Thus, we can dispose solid waste as well as liquid waste into useable form of organic fertilizer. The micro elements Co, Cu, Fe, Mn, Mo, Ni, and Zn are useful for plant growth and development, but required in limited quantity (Namira Arif,Vaishali Yadav et al 2016).

Treated press mud improves phosphorous availability, yield of crops viz: wheat, green gram, sugar cane and increase yield of sun flower seed protein, oil content (Mishra et al. 1982). Use of treated press mud is observed to increase vegetable yields such as that of Abelmoschus esculentus (bhendi) (Ramnathan et al. 2019).

Conclusion:

RPM and TPM sample were composed of plant nutrients like organic carbon, nitrogen, sulphur, chlorine, nickel, copper, zinc, selenium, bromine, strontium, molybdenum, tin, antimony, barium and oxides of SiO_2, Al_2O_3, K_2O, CaO, MgO, P_2O_5, MnO, Fe_2O_3. Physico-chemical characteristics and micro and macro nutrients of raw press mud and treated press mud varied to mill to mill of different sugar factory. Elemental compositions of raw and treated press mud elemental composition varied due distillery spent wash element contents in it. Absence of antimony in RPM2, RPM4 and barium in TPM2. Heavy metal elements are present in low concentration in RPM and TPM samples viz: Co, Cu, Fe, Mn, Mo, Ni, Zn and toxic Pb, so can’t negatively affect the plants growth. Availability of plant nutrients, RPM and TPM used as eco-friendly, healthy and sustainable agriculture practice. The composition of RPM and TPM for different industries are observed to be different due to differing cane quality and processing techniques.

Table 1: Physico-chemical analysis and Energy Dispersive X-ray fluorescence (ED-XRF analysis) of RPM and TPM

Sr.No.	Sugar Factory	Symbol	Unit	RPM1	TPM1	RPM2	TPM2	RPM3	TPM3	RPM4	TPM4
	District			Pune	Pune	Pune	Pune	Solapur	Solapur	Solapur	Solapur
1	pH	-	-	6.36	7.66	9.14	8.08	6.56	7.25	7.46	8.04
2	Electrical conductivity	E.C	S/m	0.75	1.61	1.88	2.02	1.14	1.64	1.07	2.59
3	Organic Carbon	OC	%	12.1	6.21	13.21	4.51	14.27	7.85	15.38	6.83
4	Nitrogen as N	N	%	2.21	1.01	3.45	2.42	3.42	2.01	2.62	1.35
5	Silicon	SiO_2	%	5.123	7.109	5.784	13.14	5.747	25.69	5.868	6.385
6	Aluminium	Al_2O_3	%	0.3643	0.4282	0.3518	0.857	0.4016	2.92	0.4852	0.429
7	Potassium	K_2O	%	0.3303	2.75	2.129	2.562	0.6316	3.518	2.548	4.538
8	Calcium	CaO	%	7.738	10.88	9.723	12.72	6.593	8.453	12.58	10.46
9	Magnesium	MgO	%	0.795	1.64	3.27	1.998	0.773	1.366	2.681	2.298
10	Phosphorus	P_2O_5	%	4.409	5.4	3.199	3.91	2.895	3.542	5.856	4.675
11	Manganese	MnO	%	0.06389	0.07885	0.05596	0.06716	0.05117	0.05898	0.05518	0.04754
12	Iron	Fe_2O_3	%	0.6698	0.7839	0.7966	1.518	0.8845	0.85	1.014	0.9184
13	Sulphur	S	ppm	6002	14300	22020	35050	9525	17760	15890	36080
14	Chlorine	Cl	ppm	1573	12050	9446	12210	3265	12250	13520	19520
15	Nickel	Ni	ppm	6.8	10.4	8	13.4	7.7	8.7	7.9	8.4
16	Copper	Cu	ppm	86.4	76	74.4	70.9	76.2	96.4	69.5	75.3
17	Zinc	Zn	ppm	97.1	106.4	83.7	107.5	109.2	163.3	127.7	108
18	Selenium	Se	ppm	3.3	28.9	21.9	29.1	5.8	20.9	16.3	23.9
19	Bromine	Br	ppm	3.6	16.4	12	17.3	5.5	44.6	16.7	24
20	Strontium	Sr	ppm	72.8	107.1	61.6	108	53.2	89.8	86.3	88
21	Molybdenum	Mo	ppm	1.7	4.4	3.3	4.4	2.3	4.6	2.9	6.1
22	Tin	Sn	ppm	11.4	12.5	15.6	16.4	12.4	15	13.7	17.7
23	Antimony	Sb	ppm	5.4	11.8	0	10.9	8.8	10	0	12.3
24	Barium	Ba	ppm	31.1	87.5	63.8	0	73.8	320	58.6	90.7
25	Lead	Pb	ppm	3.4	4.4	7.9	11.6	5.1	17	6.9	7

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