IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

PYROLYSIS OF MUNICIPAL SEWAGE SLUDGE FOR BIO OIL PRODUCTION AND CHARACTERIZATION OF BIO-OIL

Mr. Prince Priyroy Chauhan, Prof. Dharmesh Kapatel, Mr. Smit Christian, Mr. Darshan Chaniyara

Lecturer, Lecturer, Lecturer,
Chemical Engineering Department,
Parul Institute of Technology, Vadodara, India
Prof. Dharmesh Kapatel
Department of chemical engineering
GCET, vallabh vidhyanagar, Gujarat, India

Abstract: Municipal sewage sludge (MSS) is waste by-product produced from Municipal sewage treatment plant. Municipal waste water contains lots of hazardous impurities. So, it is necessary to treat domestic waste water in waste water treatment plant. Sewage sludge is destructive to the environment, because it contains high concentrations of heavy metal, organic pollutants and pathogens. Sewage sludge disposed by various methods such as agriculture use, landfill, and incineration are creating air or soil pollution. There are various methods available such as pyrolysis and gasification to convert municipal sewage sludge into useful products such as bio-oil, charcoal and syngas. Bio-oil can be used as fuel. Pyrolysis technology offers a practical and substitute method for stabilization and resource consumption of sewage sludge. Pyrolysis is an effective and feasible measure to immobilize heavy metals in residue and reduce toxicity to the environment. This paper is about characterization of municipal sewage sludge as well as characterize bio-oil which is produced by pyrolysis. Material characterization includes proximate and ultimate analysis of municipal sewage sludge and bio-oil.

Index Terms **- Municipal Sewage Sludge (MSS), Pyrolysis, Bio oil, Characterization**

1. INTRODUCTION

Municipal sewage sludge is a waste by-product released from municipal waste water treatment plant. A waste water treatment plant received polluted waste water from the urban area, generated from different sources such as domestic, industrial, hospital, commercial and agricultural in the form of water, detergents, pharmaceuticals and human excreta etc. Population increases day by day and rapid urbanisation creates certain problems such as, increasing volume of municipal waste water produces by urban society. So, waste water treatment plants increase rapidly in India and production of sludge also increases. The increasing amount of sewage sludge produced by waste water treatment plant creates a problem because sludge has a potential to affect human health and pollute the environment. Because sludge contains microorganisms and harmful substances, such as poorly biodegradable materials, heavy metals, bacteria, pharmaceutical, virus and hormones. Therefore, disposal of sludge in economic and efficient way is necessary. Sewage sludge disposed by various methods such as agriculture use, landfill, and incineration are creating air or soil pollution. Combustion of sewage sludge is also one disposal option. But it releases large number of harmful gases to the environment. Open dumping at sea site is another option; however, it creates air pollution as well as soil pollution at dumping site. Pyrolysis of sludge is modern handling treatment, which produced fuels. Bio-oil is a by-product obtained from pyrolysis of sludge. Characteristics of bio-oil are high oxygen containing components, high nitrogen containing components, high water content, low calorific value compare to conventional fuels. Also, yield of bio-oil produced by pyrolysis of sludge is low, because sludge contains a large amount of ash. It is necessary to improve the quality and yield of sludge pyrolysis oil. These can be improved by modification of pyrolysis process called as co-pyrolysis. In co-pyrolysis various biomass are added to sewage sludge to improve the quality of bio-oil. Pyrolysis oil is used in boilers and furnaces, but cannot use directly in gas engine and turbine due to its poor quality (Lin et al., 2018).

Figure 1.1 shows data of produced sludge in India. There is around 61754 million litre of sludge generated every day in India. Out of 61754 MLD sludge, only 22963 MLD sludge is being treated in waste water treatment plant. Around 4119 MLD of sludge generated in Gujarat, but treatment capacity in Gujarat is only 3062.92 MLD.

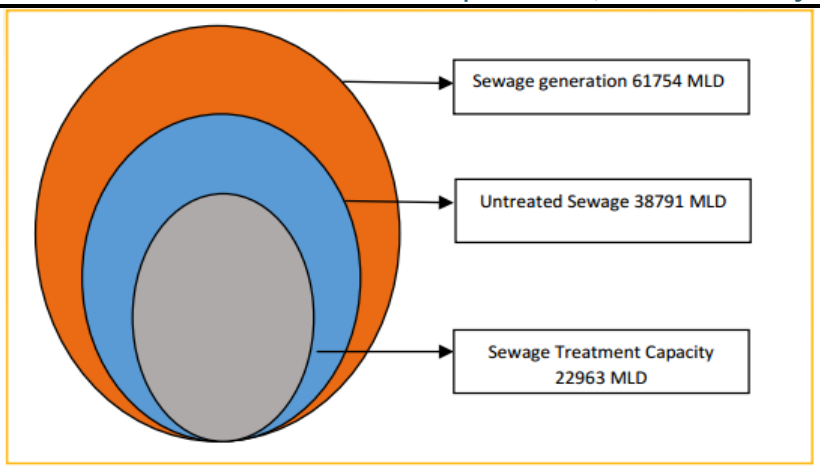

Fig. 1: sewage sludge generation and treatment

2.ALTERNATE METHOD FOR MUNICIPAL SEWAGE SLUDGE (MSS) DISPOSAL

Thermo-chemical conversion of MSS into energy and fuel has been considered as one of the most promising technology to handle a large amount of sludge generated at waste water treatment plant. Thermo-chemical treatment offers volume reduction as well as pathogens removal from sewage sludge (Samolada MC and Zabaniotou AA, 2014). Via proper technology, valuable metals and nutrients can also be recovered. New efficient and environment friendly process for sludge disposal must to be developed. Thermal processes, such as pyrolysis and gasification are gaining popularity, as the products may be use as bio-fuels and other useful products (P Manara, A. Zabaniotou, 2012). Thermal methods are better than other methods such as land filling and dumping because of its improvement in reduction of waste volume and energy production (Werther J, Ogada T., 1999). Sludge pyrolysis offer bio-oil, which is can be used as alternative to fossil fuel.

3. PYROLYSIS

Pyrolysis is one type of thermal process in which raw material is heated at high temperature in absence of oxygen (inert atmosphere). Pyrolysis products are gas, bio-char and bio-oil. Most of the heavy metal remains in solid residue at the end of process. Pyrolysis temperature is generally in a range of 400 to 1000°C. Product yield depends on heating rate, temperature, residence time, inert gas flow rate. Nitrogen gas is used as an inert gas. Combustion of sewage sludge produces only energy, but pyrolysis of sludge produces different useful products such as bio-oil, bio-char and gas.

4. METHOD OF PRODUCTION

4.1 MUNICIPAL SEWAGE SLUDGE

Municipal sewage sludge was collected from municipal waste water treatment plant, Atladra, Vadodara. It was comprised mostly of water. This sludge was collected after secondary treatment in municipal waste water treatment plant. Secondary sludge was dried under direct sun for three days to remove moisture. Secondary sludge is also called activated sludge. Sludge is a heterogeneous mixture of various organic and inorganic compounds such as protein, carbohydrates, lipids, bacteria, pharmaceuticals and hormones etc. Ash concentration of sludge is very high.

Fig 2: Municipal sewage sludge

4.1.1 MUNICIPAL SEWAGE SLUDGE CHARACTERIZATION

Municipal sewage sludge has carbonm content 23.70. Hydrogen content is about 4.78. And it is having low nitrogen content. MSS contain high amount of oxygen, which is 69.4.

Table 1: MSS characterization

Composition	**Municipal sewage sludge (%)**
Carbon	23.70
Hydrogen	4.78
Nitrogen	2.12
Oxygen	69.4
Moisture	0.28
Volatile matter	42.9
Fixed carbon	5.1
Ash	51.72

4.2 BIO-OIL PRODUCTION BY PYROLYSIS

Fig 3: pyrolysis setup

Sludge was dried in hot air oven at 105ºC for 2 hr to remove additional moisture content. After drying, materials were crushed and then average particle size analysis measured by sieve analysis. Pyrolysis setup contains reactor, condenser and temperature indicator with thermocouple. Reactor is made of stainless-steel material. Height of reactor is 300 mm with diameter of 160 mm. Condenser is also made of stainless steel. Temperature indicator with thermocouple is attached with reactor for temperature measurement. There are three pyrolysis products such as liquid, solid residue and gas. There are various experiments performed for sludge and bagasse as well as in different blending ratio of their mixture. There is total three experiments performed and products yields are shown in percentage. Pyrolysis experiment is performed for 120 minutes. All experiments are performed for 470ºC. 300 gm of feed fed into the reactor for experiment. Liquid and solid yield was calculated by mass balance and gas yield was yield based on difference.

Table 2: Experimental data of pyrolysis

Experiment Run no.	Sample	Sample weight (gm)	Liquid yield (gm)	Liquid yield (%)	Solid residue (%)	Gas (%)*
1	Pure sludge	300	51.7	**17.23**	26.2	56.57
2	Pure sludge	300	50.5	**16.83**	28.1	55.07
3	Pure sludge	300	51.1	**17.03**	27.4	55.57

4.3 BIO-OIL SEPARATION FROM PYROLYSIS LIQUID

Pyrolysis liquid contains two phases: bio-oil phase and aqueous phase. Major part of pyrolysis liquid is aqueous phase and it contains mostly water. Liquid phase has high calorific value and aqueous phase has very low calorific value. So, it is necessary to separate oil phase from aqueous phase. There are lots of methods available in literature for bio-oil separation. But very few methods could be used at laboratory scale level. Here, two methods are used to separate bio-oil from pyrolysis liquid.

4.3.1 USING SEPARATING FUNNEL

In this pyrolysis experiment, 400 gm of sludge was fed in the reactor. Pyrolysis liquid added into the separating funnel and allowed to settle down for 24 hr. Bio-oil was separated from pyrolysis liquid by using separating funnel. 110 ml of pyrolysis liquid separates and give 40 ml of bio-oil. Water content is high as 70 ml. below figure shows image of bio-oil separation by using separating funnel.

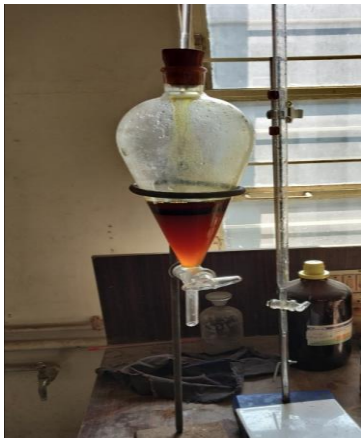

Fig. 4: separating funnel

4.3.2 USING SHORT PATH DISTILLATION

Short path distillation is used to separate water from bio-oil. In short path distillation, flask was filled with pyrolysis liquid. Equipment was operated at -100 mmHg pressure. Flask was heated by heating coil. Temperature for heating coil was set to 110ºC. Condenser tank was filled with ice cubes. At temperature around 100ºC water start to evaporate and water vapour sucked by vacuum. Water vapour comes in condenser and it condensed due to ice. Separated bio-oil remains in the flask at the end of experiment. Aqueous phase of pyrolysis oil remains in condenser. Then measure volume of collected bio-oil and aqueous phase.

Fig. 5: Short path distillation

Fig: 6 Bio oil

Fig 7 : Solid residue

Table 3: Overall bio-oil yield

Liquid produced from pyrolysis of	Liquid sample (gm)	Water (gm)	Bio-oil (gm)	Overall bio-oil yield (%)
Pure sludge	51.7	32.8	18.9	**6.3**

Table 4 :Bio-Oil Properties

Property	Bio- oil
Viscosity, cSt at 40ºC	21.3
Density, kg/m^3	1231
pH	4.5

Due to high density and viscosity pyrolysis oil may create difficulties in pumping in engine and also affect the combustion quality of oil. This bio-oil is acidic in nature.

4.4 CONCLUSION

Municipal sewage sludge pyrolysis in a fixed bed reactor is a promising decomposition route for this waste material whose production is increasing continuously. Proximate and ultimate analysis reveals that sludge has a lower amount of carbon, hydrogen and volatile matter as compared to that biomass. The experimental results showed that the highest pyrolysis liquid yield was 17.23% and solid residue 26.2%. The bio-oil produced in ml is 18.9. Overall bio-oil yield is 6.3%. Overall bio-oil yield is very low because municipal sludge has high amount of oxygen content and low amount of carbon content. So, in order to increase the yield of bio-oil biomass can be used with municipal sludge in pyrolysis reaction. Because biomass has high amount of carbon content and low amount of oxygen content. Also, Pyrolysis liquid produced from municipal sludge pyrolysis contain high amount of water. So, it is necessary to separate water from bio-oil.

REFERENCES

[1] Fan H., Zhou H., Wang J., Pyrolysis of municipal sewage sludges in a slow heating and gas sweeping fixed bed reactor. Energy Conversion and Management (2014).

[2] Lin B., Huang Q., Chi Y., Co-pyrolysis of oily sludge and rice husk for improving pyrolysis oil quality. Fuel Processing Technology 177 (2018) 275-282.

[3] National status of waste water generation & treatment (2018)

Alvarez J., Amutio M., Lopez G., Barbarias I., Bilbao J., Olazar M., Sewage sludge valorisation by flash pyrolysis in a conical spouted bed reactor. Chemical Engineering Journal 273 (2015) 173-183.

[4] J. Chen, J. Yang, H. Cai, Experimental study on pyrolysis characteristics of sludges, Journal of Zhejiang University of Technology, 33 (2005) 315 -318.

[5] Karayildirim T., Yanik Jale., Yuksel M., Bockhorn H., Characterisation of products from pyrolysis of waste sludges. Fuel 85 (2006) 1498-1508.

[6] M. Pedroza, J.F. Sousa, G.E.G. Vieira, M.B.D. Bezerra, Characterization of the products from the pyrolysis of sewage sludge in 1 kg/h rotating cylinder reactor, J. Anal. Appl. Pyrol. 105 (2014) 108–115.

[7] P. Manara, A. Zabaniotou, Towards sewage sludge based biofuels via thermochemical conversion: a review, Renew. Sust. Energy Rev. 16 (2012) 2566–2582.

[8] Rozada F, Otero M, Mor n A, et al. Activated carbons from sewage sludge and discarded tyres ： Production and optimization[J]. Journal of Hazardous Materials, (2005), B124: 181~191.

[9] Sanchez, M.E., Estrada, I.B., Martinez, O., Martin-Villacorta, J., Aller, A., Moran, A. Influence of the application of sewage sludge on the degradation of pesticides in the soil. Chemosphere 57, (2004) 673–679.

[10] Varma, A.K., Mondal P., Pyrolysis of sugarcane bagasse in semi batch reactor: Effects of process parameters on products yields and characterization of products. Ind.Crops Prod. (2016).

[11] W.N.R.W. Isahak, M.W.M. Hisham, M.A. Yarmo, T. Yun Hin, A review on bio-oil production from biomass by using pyrolysis method, Renew. Sust. Energ. Rev. 16 (2012) 5910–5923.

[12] Xiaohua W., Jiancheng J., Effect of Heating Rate on the Municipal Sewage Sludge Pyrolysis Character. Energy Procedia 14 (2012) 1648-1652.

[13] Xu, X., Zhao B., Chen X., Zhang M., Li H., Xu S., Co-pyrolysis characteristics of municipal sewage sludge and hazelnut shell by TG-DTG-MS and residue analysis. Waste Management (2017).
[14] Z. Zhang, D.J. Macquarrie, M. De Bruyn, V.L. Budarin, A.J. Hunt, M.J. Gronnow et al., Low-temperature microwave-assisted pyrolysis of waste office paper and the application of bio-oil as an Al adhesive, Green Chem. 17 (2014) 260–270