International Journal of Research in Advent Technology (IJRAT) Special Issue "ICADMMES 2018"
E-ISSN: 2321-9637
Available online at www.ijrat.org

Hydrothermal Treatment of Municipal Sewage Sludge

Raju Sodagudi [1], Kiran Kumar. P [1], Vijayakrishna.S [1], Himabindu.V[1]*
[1] *Centre for Environment, IST, JNTUH Kukatpally-500085, Telangana, India*
* *Prof. Centre for Environment, IST, JNTUH Kukatpally-500085, Telangana, India*

Abstract: Increase in population and rapid urbanization raised enormous demand for water resulting in an amount of large quantity of waste water. Treatment of wastewater results in the production of large amounts of sewage sludge. Sewage sludge disposal faces significant environmental problems related to air emissions, threat to public health and contamination of soil and water resources, therefore an appropriate treatment and careful management is required. The sludge following anaerobic treatment of waste water has high organic matter content despite initial conversion into biogas.But this does not fully harnesses its potential. Hydrothermal Treatments are a good option for converting sewage sludge into high-value products duly avoiding energy intensive dehydration process. In this study, the potential of hydrothermal processing as a novel alternative to treat the sewage sludge has been evaluated. The effect of temperatures is optimised with respect to hydrochar and process water. Treatment was carried out four different temperatures 150, 200, 250 and 300 °C at 30 min residence time. The hydro char yields were obtained to be64.27%, 61.90%, 75.72%, and 73.55% at 300°C, 250°C, 200°C &150°C respectively.

Index Terms- Sewage Sludge, Hydrothermal process, Hydro char.

1. INTRODUCTION:

Disposal of domestic sewage from cities and towns is the biggest source of pollution of water bodies in India . All Class I cities and Class II towns together generate an estimated 29129 MLD sewage (as per population in 2001 census),which is expected to be 33212 MLD at present assuming 30% decadal growth in urban population[1].This clearly indicates the dismal position of sewage treatment, which is the main cause of pollution of rivers and lakes. To improve the water quality of rivers and lakes, there is an urgent need to increase sewage treatment capacity and its optimum utilization. Treatment of municipal waste water results in large amounts of sewage sludge. The quality of the sewage sludge and the produced amount of sewage sludge estimated at about 50 g of dry matter per person per day, will not change significantly in the future [2]. Sewage sludge will remain a permanent waste problem that requires an appropriate solution. As a consequence, waste water treatment plants will have to face the very difficult task of finding alternatives to current sewage sludge treatment and final disposal routes.

Sewage Sludge is rich in organic matter and contains many toxic substances such as heavy metals, pathogens or other microbiological pollutants, persistent organic pollutants (POPs)[3-7].Sludge disposal faces significant environmental problems related to air emissions, threat to public health and contamination of soil and water resources. Over the past decade, sludge management at waste water treatment plants has been considered one of the biggest concerns for water & sewage boards and pollution control boards.

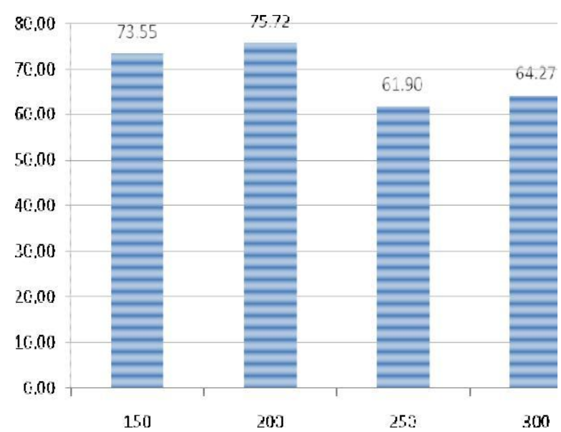
MunicipalSewage sludge can be used for the production of bio-energy due to its high organic matter content. The integration of a hydrothermal treatment step into waste water systems has been suggested to be energy positive[2,8]. Hydrothermal treatments (HT) are considered an alternative technology to harness energy from sewage sludge in the presence of water and avoid the energy-intensive drying step required for other thermal processes[10]. The main aim of the hydrothermal processing routes is energy densification via hydrochar production[9], which is produced largely by the removal of oxygen. After HT, the resulting hydrochars show moderate calorific value and are biologically inert, so they can be co-fired with coal or safely disposed in agricultural land as soil amendment.

This research is aimed at making a contribution in that regard and hence, investigates the effect of process temperature on the characteristics of hydrochars from hydrothermal processing of sewage sludge and compares the yields and characteristics of different product

2. MATERIALS & METHODS:

2.1. Sludge sample

Sewage Sludge samples were collected from UASB reactors processing Municipal sewage at 339 MLD Amberpet Sewage Treatment Plant, Hyderabad City, Telangana State.



2.2. Hydrothermal reactor setup and methodology:

Hydrothermal experiments were conducted in a stirred 500 mL stainless steel batch reactor. In each batch experiment, 250 mL slurry of sewage sludge containing 8.5% solids were loaded in the reactor and sealed. The hydrothermal experiments were conducted at 150 °C for 30 min at 5 bar, 200 °C for 30 min a t 35 bar; 250 °C for 30 min at 40 bar and 300 °C for 30 min at 80 bar. After treatment, the reactor was cooled down to 25 °C and the slurries were filtered. Process wa ter and hydrochar were collected for characterization. The experiments were conducted in triplicate.

2.3. Characterisation of Hydro Char

Sewage sludge and the slurry following hydrothermal treatments were characterised according to standard analytical methods (APHA) for Chemical Oxygen Demand (COD), Total Solids (TS), Suspended Solids (SS), Volatile Solids (VS), Volatile Fatty Acids (VFAs), Nitrates, Sulphates, Phosphates, Ammonium and pH[11].

Elemental analysis for Carbon (C), Hydrogen (H), Nitrogen (N) and Sulphur (S) were performed for dry sludge and hydrochar.Proximate analyses were performed as per ASTM standards to determine moisture, ash and volatile matter and fixed carbon.

2.4. Data processing and analysis

Data processing from hydrochar analyses was made using the following equations[12].

2.6.1. Hydrochar yield

Hydrochar yield (Y) was determined as follows:

$$Y\,(\%) = \frac{\textit{mass of dry hydrochar}}{\textit{mass of dry Substrate feedstock}}\,100$$

3. Results and discussions

3.1. Hydrochar characteristics

The proximate analysis viz. volatiles, ash content and hydrochar yields were presented in Table 1[13,14]. Hydrochar yields are influenced by reaction temperature. Hydrochar yields decrease with increasing temperature. In this work, the highest yield of hydrochar was obtained at 473 K (75.72%) followed by the yields reported at 150 °C (73.55%),250 °C (61.9 0%) &300 °C (64.27%).

Temperature(^{o}c)

	Calorific Value(MJ/Kg)
Sludge	10
Hydrochar (200 oC)	11

The ash content was increased after hydrothermal carbonisation as shown in Table 1, from 49% in the feedstock to 62%. The volatile matter content of the hydrochar was decreased after thermal treatment, having the lowest value at 300 °C (28%) followed by the results found at 150 °C (39%), 200°C (33%) and at 250 °C (31%). Thereduction of volatile matter is du e to chemical dehydration and decarboxylation and the increase in fixed carbon (FC).

Table:1.Proximate analysis of the sludge and hydro char

% wt	Sewage Sludge	150 (^{o}C)	200 (^{o}C)	250 (^{o}C)	300 (^{o}C)
Moisture Content	2.20	2.90	2.00	1.40	1.30
Ash Content	49.00	50.00	56.00	58.00	62.00
Volatile Matter	41.00	39.00	33.00	31.00	28.00
Fixed Carbon	7.80	8.10	9.00	9.60	8.70

3.2.2. Energy characteristics of hydrochar

The calorific values (HHV) of the dry feed stock and hydrochar produced at optimum condition (200^{o}C, 30 minutes) were presented in Table 2. However, Calorific value is feedstock dependent and not true for all feedstocks. Many authors have shown a reduced heating value for hydrochars produced from certain feedstocks compared to the original feedstocks[15]. In this case, the HHV of the hydrochar was increased slightly. The HHV of the original sludge is increased from 10 MJ/Kg to 11 MJ/Kg representing only a marginal energy densification. Assessment of thecombustion behaviour of this fuel has not been performed. The hydrocharwould beclassified as a low-quality fuel as it would contain ash from 49 to 62%. This indicates that for sewage derived solids andsludges, the energy densification is quite low compared to otherfeedstocks and indicates that a significant amount of the energy in theoriginal feedstock is in the soluble water fraction (process waters),which may be recovered via anaerobic digestion[14].Energy densification takes place when the solid mass decreases as a result of dehydration and decarboxylation reactions; that means the carbon content increases and the hydrogen and oxygen content decrease. Therefore, temperature and reaction time have significant influence on the energy densification of the hydrochar[16]. However, it has to be taken into account that secondary sludges have a lower carbon content compared with primary sewage sludges due to anaerobic digestion in which organic carbon is released during its conversion into biogas (CH4 and CO2).

Table 2 Calorific value of the sludge and hydro char

4. Conclusions

Hydrothermal treatments improved the characteristics of thesewage sludge producing hydrochars and process waters rich in organicmatter. Hydrothermal treatment is considered an alternative technology to harness energy from Sewage Sludge in the presence of water and avoid the energy-intensive drying step required for other thermal processes. After HT, the resulting hydrochars show moderate calorific value and are biologically inert, so they can be co-fired with coal or safely disposed in agricultural land as soil amendment

References:

[1] Central Pollution Control Board - A Report on status of STPs, dated 12-09-17.

[2] Wim Rulkens Sewage Sludge as a Biomass Resource for the Production of Energy: Overview and Assessment of the Various Options†. Hydrothermal carbonization of anaerobically digested

[3] DEFRA. Waste water treatment in the United Kingdonm - 2012 [Online]. London:Department for Environment, Food & Rural Affairs; 2012. Available:<https://www.gov.uk/government/uploa ds/sy stem/uploads/attachment_data/file/69592/pb13811 -waste-water-2012.pdf> (Accessed 3/08/2015 2015).

[4] Kim D, Lee K, Park KY. Hydrothermal carbonization of anaerobically digestedsludge for solid fuel production and energy recovery. Fuel 2014;130:120–5. [3] Hindle M. Anaerobic digestion i n the United Kingdom. BioCycle 2013;54:41–3.

[5] Mumme J, Titirici M-M, Pfeiffer A, Lüder U, Rez a MT, Mašek O. Hydrothermalcarbonization of digestate in the presence of zeolite: process efficiency and compositeproperties. ACS Sustain Chem Eng 2015;3:2967–74.

[6] Dichtl N, Rogge S, Bauerfeld K. Novel strategies in sewage sludge treatment. CLEAN– Soil, Air, Water 2007;35:473–9.

[7] He C, Giannis A, Wang J-Y. Conversion of sewage sludge to clean solid fuel usinghydrothermal carbonization: hydrochar fuel characteristics and combustion behavior.Appl Energy 2013;111:257–66.

[8]Pilli Sridhar, Yan Song, Tyagi RD, Surampalli RY. Thermal pretreatment of sewagesludge to enhance anaerobic digestion: a review. Crit Rev Environ Sci Technol2015;45:669–702

[9] M.A. Camargo-Valero- Evaluation and comparison of product yields and bio-methane potential in sewage digestate following hydrothermal treatment

[10] He C, Giannis A, Wang J-Y. Conversion of sewage sludge to clean solid fuel using hydrothermal carbonization: hydrochar fuel characteristics and combustion behavior. Appl Energy 2013;111:257–66.

[11] Stemann J, Putschew A, Ziegler F. Hydrothermal carbonization: process water Danso-Boateng E, Shama G, Wheatley AD, Martin SJ, Holdich RG

[12] Ekpo U, Ross AB, Camargo-Valero M. A comparison of product yields and inorganic content in process setreams following thermal hydrolysis and hydrothermal processing of microalgae, manure and digestate. Biores Technol 2015;200:951–60.

[14] Berge ND, Ro KS, Mao J, Flora JRV, Chappell MA, Bae S. Hydrothermal carbonization of municipal waste streams. Environ Sci Technol 2011;45:5696–703 .

[15] Danso-Boateng E, Shama G, Wheatley AD, Martin SJ, Holdich RG. Hydrothermal carbonisation of sewage sludge: effect of process conditions on product characteristics and methane production. Biores Technol 2015;177:318–27.

[16] Zhang J-H, Lin Q-M, Zhao X-R. The hydrochar characters of municipal sewagesludge under different hydrothermal temperatures and durations. J Integr Agr 2014;13:471–82