SMART city concepts for treatment of and resource recovery from municipal organic wastes: Experiences from IGSTC 2+2 projects

Dirk Weichgrebe[1], Moni Mohan Mondal[1], Rahul Ramesh Nair[1], S.V. Srinivasan[2]

[1]Institute for Sanitary Engineering and Waste Management (ISAH), Gottfried Wilhelm Leibniz University Hannover, Germany

[2]Environmental Engineering Department, CSIR- Central Leather Research Institute, Chennai,India

Collection, treatment and disposal systems of urban wastes as well as in other urban centers have to be managed and organized in an integrated approach. In India, organic fractions contribute to about 50wt.-% of the Municipal Solid Waste (MSW) and needs to be disposed in safe manner without polluting the environment. Wet and biodegradable fractions of organic MSW can be treated using Anaerobic digestion process while dry and fibrous fractions can be treated using thermal treatment for recovery of energy and value added products. The following two case studies are being carried out under Indo-German collaborative research projects at pilot scale level for recovery of energy and value added products from organic fractions of MSW funded by IGSTC 2+2 framework programme.

RESERVES Process

The main objective of the project is to generate bioenergy (biogas) from the bulk generators of organic fractions of municipal solid waste especially vegetable market and slaughter house and to evaluate the co-digestion of vegetable and slaughter house wastes in lab and pilot scale studies with bio extruder pre-treatment. Under this project, pilot plant has been installed at CSIR-CLRI, Chennai which consists of bio-extruder system an innovative technology as pre-treatment to improve the treatment efficiency and biogas production. The digester is equipped with two numbers of agitators for uniform mixing which mix the reactor for 5 min every one hour. This ensures the uniform mixing and distribution of substrate inside the digester.

The occurrence of the vegetable market waste was studied in detail and its valorization and nutrient recovery potential were identified. The combination of vegetable market waste with slaughterhouse waste was selected not only to treat waste that requires treatment but also to provide an adequate C/N ratio for the anaerobic digestion process. Moreover, the designed plant contains a bio-extrusion unit to increase the biodegradability of fibre containing market waste as well as to disinfect the slaughterhouse waste.

The pilot plant was operated with average capacity of 500 kg/day with mixed proportions of vegetable market and slaughterhouse wastes in 3:1 ratio. The pilot plant operation results in the specific biogas yield of 0.78 m^3/kg VS for bio-extruded waste, which is 44.4% higher than for non-extruded waste (only shredded). The composition of the methane was constantly ranged between 45 to 60vol.-%. As part of biogas purification studies, the scrubbing system composed of iron fillings and activated alumina has installed which ensures the H_2S concentration below 40 ppm. The residual digestate produced every day with a high water content of 95wt.-%-97wt.-% is dewatered using a screw press and the collected liquid and solid digestate are used as manure for plant growth.

PYRASOL Process

In this PYRASOL project, simple and robust processing technologies for urban organic waste is combined in a synergetic manner and further developed to improve sanitation and generate regenerative energy. In this study, innovative organic waste drying system using the solar natural chimney effect followed by an efficient single-chamber pyrolysis is designed to convert OFMSW into value added product and reduce the carbon footprint from Smart Cities. As in RESERVES project, main waste fractions in PYRASOL are fibrous organic waste from vegetable market but here combined with sewage sludge. The project aims to offer an innovative solution to transform urban organic solid waste (fibrous waste and sewage sludge) into biochar and energy in urban areas. Pyrolysis of OFMSW will generate biochar and therefore sequestrate 30% of the input carbon. This process will thereby reduce the greenhouse gas considerably. Thus, the optimum process and operation parameters of the solar updraft dryer are being studied and pyrolysis process with a unique condensing boiler technology CBT has been developed and investigated. This is supplemented through a comprehensive evaluation of the value-added chain from urban organic waste into biochar and energy and the application of biochar for land reclamation. This project contributes to Zero Waste Approaches of Smart Cities in India as the generated biochar and heat energy are consequently utilized. The energy can be used to support the drying process at night but also for chilling of vegetable market stores to avoid fruit spoilage.

Combined (RESERVES and the PYRASOL) Approach

After both approaches have been intensively studied, there is also the prospect of their combination or the establishment of a treatment center for OFMSW.

Dependent on the characteristics of OFMSW (easy biodegradable, hygienic relevant, containing fibers and lignin, containing nutrients (e.g. N, P, K) etc.) the waste fraction is sent to the appropriate treatment method. As products are generated i.e., biogas as energy carrier, liquid digestated to recover nutrients, solid digestate to recover nutrients by composting, biochar to improve the compost or for direct land application as well as heat for internal reuse or for external energy supply.