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Personal Statement: An enthusiastic, ambitious and fast-learning person with a broad and acute interest in the research and development as well as in teaching. A dedicated scholar with around seven years of experience in working for different aspects of solid waste management to solve new challenges. Possessing excellent writing skills, which is evident from publications in high impact factor SCI listed journals. Proactive leader and team player with good interpersonal skills, an integral to success of teaching and research initiatives.

Educational Qualifications:

- **Ph. D** in Environmental Science and Engineering

  (From July, 2015 to Oct., 2021)

  Name of the University/Institute: Indian Institute of Technology (Indian School of Mines) Dhanbad, Jharkhand, India.

  Dissertation Title: Assessment of Generation Rate, Energy Recovery Potential and Environmental Impacts of Municipal Solid Waste for Better Management.

  Status: Thesis Submitted

- **M. Tech** in Environmental Science and Engineering

  (From July, 2013 to June, 2015)

  Name of the University/Institute: Indian Institute of Technology (Indian School of Mines) Dhanbad, Jharkhand, India.

  Division: First class with Distinction (CGPA: 9.1 Out of 10).

  M.Tech Dissertation Title: Impact of Socioeconomic Parameters on Generation and Characteristics of Municipal Solid Waste.

- **B. Tech** in Mechanical and Automation Engineering

  (From August, 2008 to May, 2012)

  Name of the University/Institute: Guru Gobind Singh Indraprastha University, Delhi, India.

  Division: First class (Percentage: 75%).

- **B.E.** in Civil Engineering **(From Sep., 2017 to March, 2021)**

  Name of the University/Institute: Institution of Engineers (India) (AMIE), Kolkata, India.

  Division: First class (CGPA: 7.55 out of 10).

Professional Experience:

- Graduate Engineer Trainee in Coca Cola, Ghaziabad, India.

  (From June, 2012 to January, 2013)

  Role: In-charge of high-pressure compressor, production line.

Teaching and supervision Skills:

- Took tutorial and practical classes of undergraduate students.
- Taught and supervised undergraduate and post-graduate students in conducting laboratory experiments.
- Supervised two undergraduate and five post-graduate students for their research related activities.
- Prepared syllabus and course materials of different subjects of waste management.
- Presently writing a Text Book on Solid Waste Management.
- Subjects comfortable in Teaching: Environmental Engineering, Solid Waste Management, Advanced Environmental Modeling Methods.

Technical Skills:

- Life Cycle Assessment: Environmental and economic analysis of waste management systems.
- Prediction modelling using Machine Learning technique (Artificial Neural Network).
- Knowledge of statistical and empirical modelling techniques.
- Environmental Impact Assessment and Environmental Management plan.
- Knowledge of operations of waste to energy systems.

Other Skills and Knowledge:

- **Communication skills:**
  - Strong communication/presentation skills: Presented research outcomes at national and international level.
  - Good scientific writing skills: Published research and review articles in peer-reviewed journals of international repute (SCI), Knowledge of writing project proposal for various Government Bodies.
- **Management skills:**
  - Managed and performed various administrative works assigned such as lecture material & tutorial preparation, conducting of examination, preparation of results, overlooked & manged training programs and workshops conducted in the department.
- **Software and tools:**
  - Life Cycle Assessment (LCA) Software: SimaPro
  - Statistical Software: SPSS, Origin, R.
  - MS Office.
- **Additional Achievements:**
  - Reviewer of several SCI listed Journals such as Waste Management (IF: 7.145), Energy (IF: 7.147), Energy Sources, Part A: Recovery, Utilization, and Environmental Effects (IF: 3.447).
  - Graduate Aptitude Test for Engineers (GATE) Qualified.

Professional Affiliation:

- Associate Member of Institution of Engineers India (Ltd.).

- Member of International Solid Waste Association.

Publications:

International Journals (Google Scholar Citations: 696)
Google Scholar Link:
https://scholar.google.co.in/citations?user=taweTDQAAAAJ&hl=en

- **Kumar, A.**, and Samadder, S. R. **(2020)**. "Performance evaluation of anaerobic digestion technology for energy recovery from organic fraction of municipal solid waste: A review". **Energy** (Elsevier), 197, 117253. **(Impact Factor: 7.147). Citations: 88 [SJR: Q1].**

- **Kumar, A.**, Samadder, S. R., Kumar, N., and Singh, C. **(2018)**. "Estimation of the generation rate of different types of plastic wastes and possible revenue recovery from informal recycling". **Waste Management** (Elsevier), 79, 781-790. **(Impact Factor: 7.145). Citations: 51 [SJR: Q1]**.

- Khan, D., **Kumar, A.**, and Samadder, S. R. **(2018)**. "Public Acceptance Study of Environmentally Suitable Landfill Sites: A Case Study". **Current Science** (Indian Academy of Sciences), 115 (11), 2122-2129. **(Impact Factor: 1.102). Citations: 2 [SJR: Q2].**

- **Kumar, A.** and Samadder, S. R. **(2017).** "An empirical model for prediction of household solid waste generation rate- A case study of Dhanbad, India". **Waste Management** (Elsevier), 68, 3-15. **(Impact Factor: 7.145). Citations: 59 [SJR: Q1].**

- **Kumar, A.**, and Samadder, S. R. **(2017)**. "A review on technological options of waste to energy for effective management of municipal solid waste". **Waste Management** (Elsevier), 69, 407-422. **(Impact Factor: 7.145). Citations: 345 [SJR: Q1].**

- Khan, D., **Kumar, A.** and Samadder, S. R. (**2016**). "Impact of socioeconomic status on municipal solid waste generation rate". **Waste Management** (Elsevier), 49: 15-25. (**Impact Factor: 7.145). Citations: 151 [SJR: Q1].**

Conferences:

International Conference:

- **Kumar, A.**, and Samadder, S. R. **(2019)**. "Effect of Cow Dung Inoculum on Biogas Generation from Anaerobic Digestion of Organic Fraction of Municipal Solid Waste – A Case Study of India" June 26-29, 2019. International Conference on Sustainable Solid Waste Management, Heraklion, Crete Island, Greece.

- **Kumar, A.**, and Samadder, S. R. **(2016)**. "Do socioeconomic parameters govern the generation rate and characteristics of municipal solid waste?" April 1 – 2, 2016. International Conference on Waste Management (RECYCLE 16). Indian Institute of Technology, Guwahati, India.

National Conference:

- **Kumar, A.**, Kumar, N., & Samadder, S. R. (2016). "Assessment of status of municipal solid waste management in Dhanbad city" December 17 – 18, 2016. National Seminar on Environment and Development in Eastern India (Status, Issues and Challenges). Ranchi University, Ranchi, Jharkhand, India.

- **Kumar, A.**, & Samadder, S. R. (2018). "Municipal solid waste generation and composition based on family socioeconomic profile: a case study of Dhanbad" August 11-12, 2018. National Conference on Biogeochemical Cycles and Climate Change. Indian Institute of Technology (Indian School of Mines), Dhanbad, Jharkhand, India.

Waste Management 69 (2017) 407–422

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

A review on technological options of waste to energy for effective management of municipal solid waste

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ARTICLE INFO

Article history:
Received 21 April 2017
Revised 25 August 2017
Accepted 26 August 2017
Available online 5 September 2017

Keywords:
Municipal solid waste management
Waste to energy
Waste to energy technologies
Developing countries
Developed countries
Review

ABSTRACT

Approximately one-fourth population across the world rely on traditional fuels (kerosene, natural gas, biomass residue, firewood, coal, animal dung, etc.) for domestic use despite significant socioeconomic and technological development. Fossil fuel reserves are being exploited at a very fast rate to meet the increasing energy demands, so there is a need to find alternative sources of energy before all the fossil fuel reserves are depleted. Waste to energy (WTE) can be considered as a potential alternative source of energy, which is economically viable and environmentally sustainable. The present study reviewed the current global scenario of WTE technological options (incineration, pyrolysis, gasification, anaerobic digestion, and landfilling with gas recovery) for effective energy recovery and the challenges faced by developed and developing countries. This review will provide a framework for evaluating WTE technological options based on case studies of developed and developing countries. Unsanitary landfilling is the most commonly practiced waste disposal option in the developing countries. However, developed countries have realised the potential of WTE technologies for effective municipal solid waste management (MSWM). This review will help the policy makers and the implementing authorities involved in MSWM to understand the current status, challenges and barriers for effective management of municipal solid waste. This review concluded WTE as a potential renewable source of energy, which will partly meet the energy demand and ensure effective MSWM.

Contents

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http://dx.doi.org/10.1016/j.wasman.2017.08.046
0956-053X/

Energy 197 (2020) 117253

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Review

Performance evaluation of anaerobic digestion technology for energy recovery from organic fraction of municipal solid waste: A review

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ARTICLE INFO

Article history:
Received 6 September 2019
Received in revised form
27 January 2020
Accepted 24 February 2020
Available online 25 February 2020

Keywords:
Anaerobic digestion
Co-digestion
Inhibition
OFMSW
Pre-treatment
Process parameters

ABSTRACT

Anaerobic digestion is one of the most effective and environment-friendly waste management techniques. It not only treats the organic fraction of municipal solid waste, but at the same time it can be considered as one of the potent renewable energy sources due to generation of methane during digestion process. The technology is not new and has been commercialised from early 1980s. But, the data suggests that it is not still widely applied for energy recovery from organic wastes at centralised level. The reason may be poor methane yield due to operational issues and process instability. There were numerous studies already done at the lab scale, now it is the time to replicate the outcomes of lab-scale studies to the full scale plant. Further studies are required to make the anaerobic digestion techno-economically sustainable. This paper presents a detailed review of essential process parameters and identifies gaps and solutions for effective implementation of the anaerobic digestion of organic fraction of municipal solid waste. The paper also presents the effect of co-digestion, pre-treatments and inhibition on the performance of anaerobic digestion. The paper will help the readers in understanding the process, operation and control of anaerobic digestion technology.

Contents

Abbreviations: C/N, Carbon to nitrogen ratio; COD, Chemical oxygen demand; GC, Gas chromatography; LCA, Life cycle Assessment; MSW, Municipal solid waste; OFMSW, Organic fraction of municipal solid waste; S/I, Substrate to inoculum ratio; SUBBOR, Super blue box recycling; TAN, Total ammonia nitrogen; TS, Total solids; VFA, Volatile fatty acids; VS, Volatile solids.

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https://doi.org/10.1016/j.energy.2020.117253
0360-5442/

Waste Management 68 (2017) 3–15

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

An empirical model for prediction of household solid waste generation rate – A case study of Dhanbad, India

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ARTICLE INFO

Article history:
Received 27 January 2017
Revised 15 July 2017
Accepted 20 July 2017
Available online 27 July 2017

Keywords:
Biodegradable waste
Multiple linear regression model
Solid waste generation rate
Non-biodegradable waste
Prediction
SPSS

ABSTRACT

Accurate prediction of the quantity of household solid waste generation is very much essential for effective management of municipal solid waste (MSW). In actual practice, modelling methods are often found useful for precise prediction of MSW generation rate. In this study, two models have been proposed that established the relationships between the household solid waste generation rate and the socioeconomic parameters, such as household size, total family income, education, occupation and fuel used in the kitchen. Multiple linear regression technique was applied to develop the two models, one for the prediction of biodegradable MSW generation rate and the other for non-biodegradable MSW generation rate for individual households of the city Dhanbad, India. The results of the two models showed that the coefficient of determinations (R^2) were 0.782 for biodegradable waste generation rate and 0.676 for non-biodegradable waste generation rate using the selected independent variables. The accuracy tests of the developed models showed convincing results, as the predicted values were very close to the observed values. Validation of the developed models with a new set of data indicated a good fit for actual prediction purpose with predicted R^2 values of 0.76 and 0.64 for biodegradable and non-biodegradable MSW generation rate respectively.

1. Introduction

Municipal solid waste management (MSWM) has emerged as one of the biggest challenges in many parts of the world in recent times. Like several other developing countries, India is facing a great challenge in managing the increasing quantity of municipal solid waste (MSW) due to its industrial and population growth, improvement in lifestyle, migration of people from rural to urban areas, and many other factors. The increasing trend of MSW generation is a cause of concern for urban areas in India. Ministry of Environment Forest and Climate Change (MoEFCC), Government of India, revised the previous set regulations, laws, and goals called Municipal Solid Waste (Management and Handling) Rules 2000 and framed the Solid Waste Management Rules 2016 for effective management of MSW. The revised Rules (Solid Waste Management Rules, 2016), have been extended beyond municipal areas. In the revised rules, duties of the waste generators, Central Board, State Board, Ministry of Urban Development, Municipal Corporation and local bodies have been mentioned to ensure effective implementation of the Rules and the objectives of the Swachh Bharat (a flagship program of Govt. of India for Clean India). The average waste generation rate in Indian cities varies from 0.25 kg/c/d to 0.70 kg/c/d (Yadav and Samadder, in press). At present, in India, about 62 million tonnes of MSW is generated annually and it is growing at a very fast rate, which is estimated to reach about 165 million tonnes by 2030 (PIB, 2016). The present research work has been carried out in Dhanbad Municipality, which is a part of Dhanbad Municipal Corporation (DMC). Dhanbad is the largest city and second largest urban agglomeration of the state of Jharkhand, India covering an area of 275 sq. km. DMC is comprised of 55 administrative wards with a total population of 1,162,472 (Government of India, Census, 2011). The present study area is the main urban agglomerated region within DMC (i.e., Dhanbad Municipality) consisting 11 administrative wards (Fig. 1) with a total population of 253,461. The number of households in the study area is approximately 40,000. Household waste is the major source of MSW. In Dhanbad, the quantity of solid waste generated from households alone is 65% of the total waste generated in the city (CDP, 2007). The MSW generation rate in the study area is 0.41 kg/c/d (Khan et al., 2016). At present, the study area generates around 104 tonnes/d of MSW, however, it was reported that the MSW generation rate in the study area in year 2007 was 80 tonnes/d (CDP, 2007). Currently, there is no scientific technique for waste disposal in the study area (Pande et al., 2015). Presently,

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http://dx.doi.org/10.1016/j.wasman.2017.07.034
0956-053X/

Waste Management 79 (2018) 781–790

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Estimation of the generation rate of different types of plastic wastes and possible revenue recovery from informal recycling

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ARTICLE INFO

Article history:
Received 18 May 2018
Revised 1 August 2018
Accepted 27 August 2018

Keywords:
Informal
Machine learning models
Plastic waste
Recycling
Revenue generation
Socioeconomic groups

ABSTRACT

Plastic waste generation is an inevitable product of human activities, however its management faces challenges in many cities. Understanding the existing patterns of plastic waste generation and recycling is essential for effective management planning. The present study established a relationship between plastic waste generation rate and the identified socioeconomic groups, higher socioeconomic group (HSEG), middle socioeconomic group (MSEG), and lower socioeconomic group (LSEG) of the study area (Dhanbad, India). For identification of the socioeconomic groups, four different socioeconomic parameters were considered (total family income, education, occupation and type of houses). The information related to the identified parameters were obtained using questionnaire survey conducted in the selected households. One week plastic waste sampling was carried out in the households of all the socioeconomic groups. The plastic waste generated in the study area was 5.7% of the total municipal solid waste. In terms of total plastic waste generation rate, it was found that HSEG had maximum (51 g/c/d) and LSEG had minimum (8 g/c/d) generation rate. The present study area does not have any formal waste recycling system. Thus, the amount of plastic waste recovered and the revenue generated from recycling of plastic waste by the active informal recyclers (waste pickers, itinerant waste buyers and scrap dealers) in the study area have been evaluated. Additionally, three non-linear machine learning models i.e., artificial neural network (ANN), support vector machine (SVM) and random forest (RF) have been developed and compared for the prediction of plastic waste generation rate.

1. Introduction

Various types of plastic products have become an indispensable part of lifestyle. Plastic production has increased tremendously in past 50 years. In India, approximately 12 million tonnes of plastic products are used annually and 70% of them is disposed of indiscriminately as waste (Singh et al., 2017). India being one of the fastest growing plastic market, has an annual plastic production growth rate of 16%, followed by 10% per annum for China and 2.5% per annum for UK (BPF, 2012). With such a high production rate, an established waste processing route for its recycling and recovery is necessary. Unlike the developed countries, recovery of plastic waste remains mostly an informal activity in the developing countries like India. Informal sector include unregulated and unregistered individuals or groups such as waste pickers, scavengers, itinerant waste buyers (IWBs) and scrap dealers involved in recycling of waste materials. In most of the Indian cities, the waste segregation and identification for potential recyclable items are carried out by informal sector (Nzeadibe, 2009; Nandy et al., 2015). Government of India has provided a few regulatory framework (such as Solid Waste Management Rules, 2016 and Plastic Waste Management Rules, 2016) for the management of waste generated in the country. As per the Solid Waste Management Rules, 2016 the state policies and strategies should acknowledge the contribution of the informal sector for waste recycling. For effective management of plastic waste in particular, Government of India has notified Plastic Waste Management Rules, 2016 that

Abbreviations: ANN, artificial neural network; ASTM, American Standard for Testing Material; CD, compact disc; CPCB, Central Pollution Control Board; DMC, Dhanbad Municipal Corporation; GDP, gross domestic product; HDPE, high density polyethylene; HSEG, higher socioeconomic group; INR, Indian Rupees; IWB, itinerant waste buyer; LDPE, low density polyethylene; LSEG, lower socioeconomic group; MAPE, mean absolute percentage error; MLR, multiple linear regression; MoEFCC, Ministry of Environment Forest and Climate Change; MSEG, middle socioeconomic group; MSW, municipal solid waste; PC, polycarbonate; PET, polyethylene terephthalate; PP, polypropylene; PS, polystyrene; PU, polyurethane; PVC, poly vinyl chloride; R^2, coefficient of determination; RF, random forest; RMSE, root mean square error; SVM, support vector machine; UK, United Kingdom; US, United States; USA, United States of America.

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https://doi.org/10.1016/j.wasman.2018.08.045
0956-053X/

Waste Management 49 (2016) 15–25

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Impact of socioeconomic status on municipal solid waste generation rate

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ARTICLE INFO

Article history:
Received 14 August 2015
Revised 1 January 2016
Accepted 15 January 2016
Available online 28 January 2016

Keywords:
Municipal solid waste generation rate
Socioeconomic group
Solid waste composition
Solid waste management

ABSTRACT

The solid waste generation rate was expected to vary in different socioeconomic groups due to many environmental and social factors. This paper reports the assessment of solid waste generation based on different socioeconomic parameters like education, occupation, income of the family, number of family members etc. A questionnaire survey was conducted in the study area to identify the different socioeconomic groups that may affect the solid waste generation rate and composition. The average waste generated in the municipality is 0.41 kg/capita/day in which the maximum waste was found to be generated by lower middle socioeconomic group (LMSEG) with average waste generation of 0.46 kg/capita/day. Waste characterization indicated that there was no much difference in the composition of wastes among different socioeconomic groups except ash residue and plastic. Ash residue is found to increase as we move lower down the socioeconomic groups with maximum (31%) in lower socioeconomic group (LSEG). The study area is a coal based city hence application of coal and wood as fuel for cooking in the lower socioeconomic group is the reason for high amount of ash content. Plastic waste is maximum (15%) in higher socioeconomic group (HSEG) and minimum (1%) in LSEG. Food waste is a major component of generated waste in almost every socioeconomic group with maximum (38%) in case of HSEG and minimum (28%) in LSEG. This study provides new insights on the role of various socioeconomic parameters on generation of household wastes.

1. Introduction

Municipal solid waste management (MSWM) is one of the major environmental challenges in most of the cities of developing countries like India. Improper management of municipal solid waste (MSW) causes hazards to inhabitants and environment. The solid waste management system needs to be updated to suit the waste quality, quantity and composition (Kalantarifard and Yang, 2011). The quantification of waste generation rate and characterization of its composition are essential to plan and design an effective solid waste management systems of any given region (Gidarakos et al., 2006; Gomez et al., 2008). Various authors conducted research to establish the relationship between waste generation, their composition and socioeconomic factors (Wang and Wu, 2001; Qu et al., 2009; Sujauddin et al., 2008; Saeed et al., 2009; Philippe and Culot, 2009; Ojeda-Benitez et al., 2008; Marquez et al., 2008). Medina (1997) reported that the solid waste generation is directly dependent on the income levels, and the upper-income individuals tend to consume more industrialized products, their garbage contains more recyclable materials than that of low-income communities. The consumption pattern of household is directly linked to the increase in income which results in changed composition and quantities of household waste (Ogwueleka, 2013). However, it has been found that this is not the only governing factor. Amongst other socioeconomic factors that have been said to influence MSW generation rate are number of family members, education, occupation, etc. (Bandara et al., 2007). The findings of Suthar and Singh (2015) suggest that there is a strong correlation between waste generation and family size of a household. The more a household get educated and aware of the side effect of unmanaged solid waste, the more it appreciate an effective waste management (Kayode and Omole, 2011). Viswanathan and Trankler (2003) reported that in a family with rich socioeconomic condition, daily waste generation rates are generally higher than the lower socioeconomic families.

The waste quantity is increasing at an alarming rate in India due to rapid urbanization and high population growth. The growth rate of population for India in last decade was 17.6% (Census of India, 2011). Urban waste generation rate in India is lower compared to other developing countries and approximately one-third to half that of developed countries (Asnani, 2006). A World Bank

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http://dx.doi.org/10.1016/j.wasman.2016.01.019
0956-053X/