

RESIDENTS PERCEPTION OF THE SOCIAL AND ECOLOGICAL IMPLICATIONS OFF WASTE DUMP REPOSITORY AT LEMNA WASTE DUMP SITE, CALABAR , CROSS RIVER STATE, NIGERIA

^a Mathais Oko Ukpata, Bullem Simon Bullem^b

^a Cross River State College of Education, Akamkpa

¹Department of Physical and Health Education, Cross River State College of Education, Akamkpa

²Department of Physical and Health Education, Cross River State College of Education, Akamkpa

Abstract

Waste management and control is a major environmental concern in the cities of the world. This concern emanates from the fact that waste products have far-reaching social and ecological impacts. An understanding of the waste being managed is a fundamental starting point to its effective control. This study is spurred by the need to significantly appreciate the extent of residents' awareness of the health, emotional and aesthetic implications of waste in their vicinity. Such awareness is a basic starting point of mitigation or adaptation to the menace of the waste products in their day-to-day exposure. The problem identification for this study stemmed from a cursory assessment of the residents seeming manner of insensitivity to the nuisance caused by waste as observed by the researchers in their visit to the site. Consequently, the objectives focus on the residents' appreciation of the overall impact of waste dump on their physical and mental health, emotional deterioration and so on. The study methodology considers the description of the research design, the study, population, sampling technique, instruments for data collection and the methods of data analysis. The justification for study was explained based on the valuable contribution of the research findings in urban environmental waste management, human physical and psychological health consideration, increased awareness of waste impact by residents and many more. Data analysis was based on statistical testing using the chi-square(χ^2) distribution. Following the decision rule, the null hypothesis was rejected and the alternative accepted implying that there is significant variation in the residents perception

Keyword: Waste management, Control, Environment , Ecology

Introduction

Urban waste management is a formidable challenge in all the major cities of the world and more so in developing countries such as Nigeria where appropriate technology for effective waste control is far and few

between. For effective waste control and management considerations have to be given to issues of social and ecological sustainability. Socially, cognisance have to be taken bordering on health implications deriving from the need to consider the safety of residents in terms of the air, the water and land quality considerations. Also too, there must be concern for the nature of waste species to be handled and managed. Waste speciation borders on classification of waste on the basis of environmental degradation or otherwise. In this sense, some waste are biodegradable, that is, they are reducible and degradable with time, while the non-biodegradable are enduring and non-reducible in the environment. There are also waste categories that are either noxious or harmful while others are non-lethal or harmless.

Further still that are the radioactive waste categories which are recognised to be carcinogenous, (cancer causing) mutagenic (causing gene mutation), teratogenic causing birth defects in women and so on. Overall, there must be a wide range of social consideration based on the nature of the waste being managed.

Ecologically, waste management requires a broad spectrum of analysis. Soil quality criteria on the basis of waste impact on the soil and its attendant impact on cultivars and animal life. In these sense, some waste types such as heavy metals of lead, calcium, mercury, etc are said to be bio-accumulative. Thus, they accumulate in the soil and have long half-life when they get into the food chain by the root system of plants or through aquatic species they get into the highest level of the food pyramid and cause remarkable impact on the health of the population or residents found around the repository. Ecological issues also boarder on air quality and water quality consideration. It has been recognised that any waste dump site is a heavy power house of biological and chemical activities. The bio-degradation process produce enormous chemical energy in the form of Nitric acid methane and so on. The anaerobic or putrefaction process produces enormous noxious odour that is hardly bearable to a visitor to the dumpsite. This stench or odour has significant impact on those who have been exposed to the effect for the reasonable length of time.

Biologically, the waste dump site is a bee hive of biological activities, decomposing bacteria, vermin/rodents, scavengers (human and non-human) flees of various categories, vectors, etc all have competitive niches in the waste dump locale.

Essentially, the focus of this research work is on adequate substantiation of the extent to which residents around the dumpsite perceive or are aware of the overall impact of waste on their livelihood and on the environment around. And, also to assess their extent of adaptation or mitigation of these impacts towards healthy living modes.

Statement of the problem

Calabar Urban Development Agency (CUDA) is the municipal waste management agency saddled with the collection and control of waste in the Calabar city area. The method involves collection of waste using receptacles located in strategic points. Following this, the accumulated waste in the receptacles are transferred to a mobile conveyor or waste truck which hauls the waste to the dump site at Lemna Waste Dump Site at the outskirts of the city. At the dump site, the waste is simply deposited at an open air space without speciation or treatment but open air incineration. This method of waste handling falls significantly short of the most current “state of the arts” waste management technology of the industrial incineration process which undertakes waste sorting and/or speciation. The open air method has significant implication on the health of residents around.

Besides, the above approach, consideration should have been given to suitability of siting or location of the dump site on the basis of watershed impact from the point of view of drainage or water quality assessment vis-à-vis residents’ health implications.

Furthermore, the choice of location did not take into cognisance the demographic implications of the repository and therefore the waste dump which was at the city suburb is now encircled by residential housing development thus further aggravating the impact consideration at the dump site.

Finally, a very important swing that gave impetus to the initiation of this proposal is the observation made by the research team while on a reconnaissance visit to the site. The observation involved the recognition that people were found habituating the dump site and engaged in all manner of activities which

goes to suggest that they have little or no regard about the negative health impact of the dump. It therefore becomes expedient that a study be embarked along this line to actually unravel the individual perception of the waste dump impact on the people and the landscape.

Purpose/objectives of the study

Purpose: The study is generally aimed at investigating the residents' sensibility to the overt and implicit impact of the waste dump on their health and general livelihood.

Specific Objectives: The specific objectives are as follows:

- i) To investigate the residents' awareness of the health implication of the waste dump.
- ii) To investigate the residents' awareness of the ecological impact of the waste dump site.

Justification of the study

Waste or externalities are by-products of human activities in the environment. In essence, they are a nuisance or sometimes unwanted by-products of human environmental engagements. A good knowledge of waste is a fundamental starting point to appropriate environmental behaviour and management. Air pollution effect, water quality degradation and landscape deterioration can effectively be curbed or eliminated if effective waste management measures are employed. Waste management concern has been top on the agenda of most governments and organisations the world over. Currently there are global treaties and conventions aimed at the control of international trade on toxic waste products.

Federal Environmental Protection Agency (FEPA) now Federal Ministry of Environment was formed by Decree 1 of 1991 in response to the Koko toxic waste conspiracy of that year. Waste control and management is a formidable challenges to urban municipal authorities the world over and cannot be treated with kits glove.

This study like similar others is therefore necessary as basis of environmental capacity building in that the results derived will provide insights in the academia for alternative approaches of grappling with residents susceptibility to the waste damage impact as well as appreciation of the health implications of the study. Calabar urban environmental management will derive insights as to the other possible alternative strategies of managing the waste repository for purposes of social and ecological sustainability. Equally residents' awareness was enhanced based on the results and suggestions of the study and this will go a long way to a change in attitude toward appropriate environmental behaviour. A new environmental orientation was inculcated in the general public towards curbing the spirit of poor waste management or "litter bugging".

Research hypothesis

Inline with the stated the stated. The hypothesis is stated as follows:

1. Ho: there is no significant variation in the perception of the residents concerning the psychosocial and ecological impact of residents concerning the psychological impact of the waste dump
2. Hi: there is a significant variation in the residents perception of the psycho- social/ecological impact of the waste slump in the study area.

Literature review

Meaning/conceptualization of waste

Waste has a subjective ascription (Ebikapade, 2016). This injunction derives from the recognition that what constitutes waste to one person may be considered a resource by another. Following this, it was therefore asserted that a material can be regarded as waste when the owner labels it as such (Dijekema et al, 2000). However, it has been generally recognised that what constitutes a waste is what may be seen as nuisance; something that evokes dislike in aesthetic and other considerations. It is also an established point that most human activities result in waste generation and there several categories of waste that are produced and released to the environment leading to the emergence of environmental degradation and deleterious health effects (Brunner and Rechberger, 2014).

Due to the variety of sources from which is generated, waste has amorphous composition as given by the general classification.

Waste Categorization

Waste emanates from different sources and its categorization can be expressed in different forms. In terms of states of matter, waste is categorised as solid liquid and a gaseous. In terms of source, it has been classified as house hold/domestic waste, industrial waste, agricultural waste commercial waste, demolition waste and mining waste. In terms of environmental impact it can be categorised as hazardous and non-hazardous (Ebikapade, 2016).

Following the last categorization, some are harmful while others are not. Others are degradable while some are not among the hazardous. Considering the essence of waste sources, municipal waste is among the most deleterious on public health and wellbeing if not properly managed (Tchobanoglous, 2012).

Solid waste are the most challenging on control and management because they do not disappear easily from the environment. According to Basu(2010), some solid waste are putricible while others are non-putricible. In other words, some can decay from the environment, while others do not. Municipal waste are among the solid waste categories and following Vergan and Tehobanoglous (2012), if municipal waste are not well managed, they may have negative impact on wellbeing and environment. This statement bears directly on the subject matter of this proposed study.

Similarly, White (1995) held that municipal solid waste (MSW) are difficult to manage because of the amorphous components such as paper, metal, glass and other organics.

Model of waste management and control

Waste management demand grew as people began to live in communities. As population blossomed and the purchasing power of people increased, the quantity of waste grew correspondingly. Accordingly, Marchettini (2021) pointed out that continuous flow of waste resulting from human activities overburdened the environment. On this basis, Baranek (1999) proposed that the provision of an efficient solid waste management system is as important as provision of othersocial amenities like electricity, airport and so on. There are several arguments concerning the best waste management practices. Basu (2009) held that due to continuous flow of waste and its corresponding increase in volume landfill system is quite unsustainable.

Following Demibas (2011), waste management is a process by which wastes are gathered, transported and processed before disposal of any remaining residues. In the same vain, Tchobanoglous (1993) held that solid waste do not disappear easily. He opined that sustainable solid waste management requires an adequate understanding of the characteristics sources and generation rate of the solid waste in an area. Along similar line, Geani (2014) held that proper organisation of solid waste management has been an essential task needed to safeguard the environment. These claims give direction to the necessity of a well organised management system for a city such as Calabar, Cross River State.

Waste management techniques

There are a variety of ways by which modern waste management is handled. The objective of the current waste management is on how to turn consumed goods to consumable goods in a climate change environmental scenario (Stridler and Adeoye, 2003).

Some of the modern waste management techniques are highlighted below:

Recovery through recycling: This has a great deal of environmental benefit in that it reduces or scavenges the waste from the environment. Recycling materials include plastics, papers, glass, metals and so on (Smith, 2009). There are agencies like “quality bin hire companies” that focus on separating waste according to their ability to recycle (Tiang, Tam and Xui, 2020).

Another method is biological reprocessing. This method is only applicable to waste of organic nature. The methane that comes as gaseous waste can be used for producing heat and electricity (Kaur, 2020).

A third method is sanitary landfill involving special engineering system. The system consists of lining the base of the waste dump with a protective plastic layer to reduce leakages (Hu et al, 2020).

The method of incineration involves burning the waste at high temperature. To avoid air pollution during burning proper filters are used (Hao et al, 2020).

Bioremediation involves the process of using microbes and bacteria for removing the impurities, pollutants and poisons from soil and other environments. This is applicable in areas with energy power generation where radioactive substances are produced. This technology rectifies the heavy metals pollution problem (Saim and Dhanie, 2021).

Another formidable technique is the waste to energy technology. This technology is in vogue in China and involves the use of anaerobic digestive system which helps in the reduction of greenhouse gases in factory waste treatment (Zhang et al, 2020). It involves the use of methods pyrolysis, gasification, incineration and biomethanation which helps in converting municipal solid waste (MSW) as a source of renewable energy into useful energy i.e. electricity and heat (Malar et al, 2020).

Finally, remote sensing method is used for detection and quantification of waste dump by a system aerial data capturing involving the use of vector data and remote sensing (Gautam, Brema and Dhasarathan, 2020).

Ecological and social impact of solid waste disposal

A barrage of information exists in the literature concerning ecological and human health impact of solid waste disposal in an environment. It has been reported that many cities in developing countries face environmental and health risks due to weakly developed municipal solid waste management (Nguyel et al, 2011). A similar report was provided by Ndukwe et al (2019) in his research on environmental and health impact of solid waste disposal in Umuahia and environs. The report listed among others health deterioration, accidents, flood occurrences and environmental pressures. This statement was substantiated by Foday et al (2013) who said such conditions produce gastro-intestinal, demagogical, respiratory, genetic and several other ailments. The report added that organic waste is quite deleterious in the sense that the putrefaction process involving anaerobic action produces harmful microbes and offensive odor due to the chemical reactions and those living in the vicinity of the dump site are most vulnerable and susceptible (Foday et al, 2013). Medina (2002) equally reported that pollution is a major environmental effect of dump sites. The pollutants are said to find their gateway to the human body through contaminated crops, animals and food stuffs. Goveia and Ruscito, (2009) in their findings reported that some of the common health problems associated with waste dump sites include, respiratory disorder, skin irritation, eye and nose gastrointestinal problems, psychological disorders and allergies.

Residents' Perception of the Dump Site

Perception is a subjective opinion or assessment by individuals due to their individual modalities. Ndukwe (2019) study of Umuahia had revealed the level of assessment of individual. There was a general level of agreement among the residents of the negative effect of the waste dump site on their health but his findings revealed significant disparity among the resident on the mode of waste disposal by individual household. The attitudinal orientation generally complied with the policy of environmental friendly behaviour which is otherwise for the uneducated.

METHODOLOGY OF THE STUDY

Research design

This proposed research study design aimed at investigating respondents' perception of the sociocultural and biophysical impact of refuse waste dump at the study location (Lemna Wastes Dump Site) in Calabar, Cross River State. The focus is to generate data that will yield information for decision making towards curbing the negative impact of refuse waste material in the social and physical environment in the area.

Area of study

This study is to be conducted in Calabar and its environs. Specifically the study aims at investigating residents perception or knowledge of the impact of waste dump on the environment and the people. Calabar is the capital city of Cross River State with a rapidly growing population due to its coastal/marine location as well as its administrative responsibility as the capital of Cross River State. The state encapsulates two broad ecological zones namely the marine coastal belt to the south and the savanna

hinterland belt to the North of the area. The unique characteristics of the two belts is replicated in the temperature, rainfall, winds and insolation of the areas. Specifically Lemna is located to the North East of Calabar proximately to the qua river drainage basin.

Overall, the area is topographically rugged due to frequent incidence of dissected hills interspersed with ravines here and there making the landscape appearance a typed model of “Bad land topography”. Possibility, it may have been that bad land identity that qualified it as a waste dump site but today such ascription has waned due to increased land demand which has forced urban residential sprawl to the area.

Subjects/population of the study

The overall universe of study comprises all residents living in and around the waste dump site within a radius of 2 kilometres downstream the dump and 1 kilometre upstream.

Specifically, adult residents of fifteen years and above were the target of the study. Population capturing sampling will adopt as approach by tenement selection using self-entice order of selection. Initial step to effective population sampling was field legibility survey where investigators will visit the site for purposes of establishing a rapport with the subjects.

Population sampling

Multistage technique was applied in sampling and selection of the population for the study. The first step is the purposive sampling where the area was designated into upstream and downstream clusters for data collection. Next, each cluster was delineated into blocks or semi clusters on the basis of residential characteristics and/or geodemographic identities. In each cluster or geodemographic entity, subjects were selected by household or residential systematic sampling based on the serpentine model of sampling. Finally, the motely of cluster selecting was assembled for random sampling using the method of cap and draw technique.

Instruments for data collection

Instruments employed in field data collection included the following amongst others:

- i) Questionnaires areas/checklists/observation schedule.
- ii) Geographical/Global positioning system for determination of elevation and depression.

Procedure for data collection

Data was collected in three phases as follows:

- i) Phase I – Field reconnaissance survey for field legibility assessment.
- ii) Phase II – Wet season data collection which cover two months in the middle of the wet season.
- iii) Phase III – Dry season data collection which will equally cover two months.

Data analysis

Sociocultural data such as individual perception of the dump impact was analysed through hypotheses testing and employment of appropriate statistical technique such as chi-square analyses of variable, man witness test.

Data presentation

Field data captured through questionnaire administration was represented on table 1 below.

To the left of the table are residents percapital parameters to be elicited in the course of the interview while to the right are 4 point rating scales to be responded to on the basis of their individual perceptual modes. The lettered short notations follows the 4 points likert scale which means A- agree, SA- Strongly agree, D- Disagree and SD-Strongly disagree. The values represented in numerals correspond to the number of persons who affirm to an option.

Overall a total of 100 residents who reside around the dump sit were interviewed. The table has been transposed for computation of the chi-square (χ^2) statistics in line with the stated hypothesis

Data presentation and analysis

Table 1; Residents percaptal of the psychosocial impact of waste dump in Calabar, Cross River state Nigeria

S/N	PARAMETERS LICITED	RESPONDENTS 4 POINTS RATING				
		A	SA	D	SD	TOTAL
1.	Goodness of the waste dump to residents health	10	12	28	48	89
2.	Awareness of Presence of rodents and vermins	20	29	12	36	97
3.	Presence of malaria and typhoid	28	35	72	13	98
4.	Effect on water quality	25	38	15	22	100
5.	Possibility of underground water pollution by the waste	26	29	25	16	96
6.	Possibility causing flood effect	41	38	18	3	100
7.	Destruction of aesthetic value of the environment	38	48	10	4	100
8.	Production of toxic chemical in the in air	30	36	10	20	96
9.	Effect on mental health of residents	20	28	30	20	98
10.	Pschosocial impact on childrens development progression	30	26	35	8	99
	Total	268	319	255	190	973

Hypothesis testing

The hypothesis is hereby restated in the null form as follows:

Ho: there is no significant variation in the residents perception of social/psychosocial impact of the waste in the study area.

From the table of specification above the hypothesis is tested using the technique of hypothesis is tested using the technique of chi-square (χ^2) distribution.

Data analysis

Data was analysed in line with the hypothesis stated above using the chi-square statistical techniques.

Table 2: Chi square table on Residents percaptal of the psychosocial impact of waste dump in Calabar, Cross River state Nigeria

O_{ij}	E_{ij}	$(O_{ij} - E_{ij})$	$(O_{ij} - E_{ij})^2$	$\frac{(O_{ij} - E_{ij})^2}{E_{ij}}$
10	27	-17	289	10.7
12	32	20	400	12.5
28	26	2	4	0.154
48	19	29	841	44.26
20	27	-7	49	1.81
29	32	-3	9	0.28
12	25	-13	169	6.76
36	19	17	289	15.21
28	27	1	1	0.037
35	32	3	9	0.28
22	26	4	16	0.62
13	19	-6	36	1.89
25	28	3	9	0.32

38	33	5	25	0.75
15	26	-11	121	4.65
22	20	2	4	0.20
26	26	0	0	0.00
29	31	-2	4	0.13
25	25	0	0	0.00
16	19	-3	9	0.47
41	28	13	169	6.036
38	33	5	25	0.76
18	26	-18	324	12.46
3	20	-17	289	14.45
38	28	10	100	3.57
48	33	16	256	7.76
10	26	-16	256	9.85
4	20	-16	256	12.80
30	26	4	16	50.62
36	31	5	25	0.81
10	25	15	225	9.00
20	19	1	1	0.053
20	27	-7	49	1.81
28	32	-4	16	0.50
30	26	4	16	0.62
20	19	1	1	0.052
30	27	3	9	0.33
26	32	-6	36	1.13
35	26	9	36	1.38
8	19	-11	121	6.37
χ^2				241.382

Decision rule:

The degree of freedom (r-1), (C-1) = (4-1), (10-1)= (3,9) At $\alpha = 0.05$ level of significance and degree of freedom 3,9. A table value of χ^2 (0.05, 3,9)= 0.352 , and 3.33, if the computed χ^2 is > the table χ^2 we reject the null hypothesis or otherwise if $\chi^2 > 0.352$ or $\chi^2 < 3.33$

Results/findings

The decision rule following from the hypothesis testing using the technique of chi-square (χ^2) distribution reveal that the calculated χ^2 value (0.05, 3,9)= 0.352 is less than the critical (α) t value of 3.33 at 0.05 level of significance and (r-1)(c-1) i.e (4-1)(10-1)=3,9 degree of freedom. The result indicated while the alternative hypothesis is upheld . Thus , there is a significant variation in the residents perception of the social and ecological impact of the waste dump in the area under investigation.

This result is indicative of the amorphous back ground of residents who reside around the dumpsite. Hence we have the very less educated and the very moderately learned personalities around the dump site proper. The

underlying factor is that the area was primordialially occupied the dump site when they driven by the peculiarly of their circumstance to live at the urban fringes.

In this sense Ndukwes' (2019) study of Umahia along similar lines may be partly relevant and partly not. His report revealed that residents perception of the negative effects of waste repository was homogenous while there was disparity in their idea of mode of disposal.

The entire conjecture is the uneducated resident as well as some informed ones may not understand the intricate science behind the nature of waste general and their implications human health. There is therefore need for a clear understanding the underlying facts of waste accumulation and their social and ecological implications. For instance , Foday et al (2013) has provided useful insights in to the negative health impact of waste accumulation when said that such conditions affect respiratory, genetic and several other ailments. The report went further to substantiate that organic waste is quite deleterious in the sense that the putrefaction (decaying) process involving an aerobic action produces microbes and offensive order due to the chemical reactions. Medina (2002) provided an insight with how waste accumulation can affect food chain back to man who is the climax consumer.

Health problems associated with waste accumulation include respiratory disorder, skin irritation, eye and nose irritation gastro intestinal problems, psychological disorders and allergies.

Numerous other side effects have been explored and reported in the literature. The factor of poor perception of these effects by residents in the dump site can be explained based on certain interactive tendencies which are glaring expressed in the environmental behaviour of residents and the general public towards proper waste management.

One glaring aspect is the manner in which some youths and individuals navigate an ransack the waste dump site on a daily basis. A good number have cultivated the habit of rummaging the waste dump site for reasons of economic gain. Poignantly, the waste dump site is great heaven for lunatics and other deranged personalities. Currently, outside the dump site, the degree and manner of waste accumulation along the streets and road arteries produces an eye sore and potential health problems to residents and other transits population. There is therefore need for public awareness creation and concerted governments policy framework to avert this ugly trend.

Conclusion

Waste accumulation in the areas of study is a crucial environment problem that needs urgent attention probably for lack of adequate knowledge and awareness scant attention is being paid to its careful management by governments and residents alike. This poor perception smacks ignorance and levity which demand attention and levity which demand attention to be called to its. There is need for reversal in attitude and orientation for a friendly environmental approach to waste management in the area.

References

- Basu, R. (2009). Solid Waste Management-A model study. *Sies Journal of Management*, 6, 20-24.
- Brunner, R. H. and Rechberger, H. (2014). Waste to Energy – Key elements to sustainable waste management, *Waste Manage*, 37, 3-12, <http://dio.org/1011016/wasman.2014.02.003>
- Demirbas, A. (2011). Waste Management, waste resource facilities and waste conversion processes. *Energy conversion and management*. 52(2) 1280-1287.
- Dnekem, G. P. J., Ruetter, M. A. and Versoef, E. V. (2000). A new paradigm of waste management, waste management. 20(8), 633-638, <https://dior.org/10.1016/entoman>
- Ebikapade, A. (2016). The concept of waste and waste management: *Journal of Management and Sustainability*. 6 (4), Canadian Centre of Science and Education.
- Giani, G. (2014). Operational Research in Solid Waste Management. A survey of strategic and tactical issues. *Computers and operation research*. 44(4) 22-32.
- Hao, X, Chen, O, Van, M. G. and Jian, H. (2020). Sustainable disposal of excess sludge. Incineration without anaerobic digestion, *Water Research*, 170, 115298
- Hu, J. Ke. H. Zan, L. T. Lan, J. W. Powrie W. and Chen, V. N. (2020). Installation and performance of horizontal wells for dewatering of municipal solid waste landfills in China. *Waste management*, 103, 159-168
- Kaur, T. (2020). *Wermi Composting: A effective option for recycling organic wastes in organic agriculture*. Intech-Open.
- Malave, L. C, Yadar, K. K, Gupta, N. Sharma, G, K, Krishman, S. and Bhatta-charyya, S. (2020). A review on municipal solid waste as a renewable source of waste to energy project in India: Current practices Challenges.
- Saini, S. and Dhanias, G. (2020). Cadnirim as an environmental pollution. Ecotoxicolgoical effects, health harzards and bioremediation approaches for its detox cation from contaminated sites. In *bioremediation of industrial waste for industrial safety*, 357-387, Springer Singapore.
- Stridhar, M. K. C. and Adeoge, G. O. (2003). Organo-mineral fertilizer from urban wastes development in the Niger Delta Field. 68, 91-111.
- Tang, Z. Li, W. Tam, V. W. and Zue, C. (2020). Advanced progress in recycling municipal and construction solid waste for manufacturing geopolymer composites. *Resource Conservation and Recycling: X* 100036.
- Tchobanaglou, G. and Adeoyem G. O. (1993). *Integrated Solid Waste Management Engineering Principles and Management Issues*. Water Science and Technology Library. 8(1) 63-90
- Vergara, S. E. and Tchobanaglou, G. (2012). *Municipal Solid Waste Management and Environment. A global perspective*. *Environment and Resources*. 37 (37) 277-309.
- White, P. R. (1995). *Integrated Solid Waste Management. A life cycle inventory*, Berlin, Springer.
- Zang, J. Zhang, S. and Liu, B. (2020). Degradation technologies and mechanism of dioxin in municipal solid waste incineration fly ash. *Journal of cleaner production*, 250, 119507.