Solid Waste Characterization at University of Technology-Iraq - Step for Sustainable Development

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Abstract: Solid waste accumulation is increasing year rapidly and poses a crucial threat to a healthy life, and exhausts natural resources. Major steps must be taken to initiate a new human manner and habits to reduce, recycle, and reuse waste as a part of sustainable development. This research discusses the activity initiated at the Chemical Engineering Department - University of Technology - Baghdad Iraq to engage faculty members and students at solid waste management's approaches through adopt classification and sorting of the solid waste at the source. The second stage was to analyze the amounts and types of accumulated solid waste at the chemical engineering department building for one semester starting from 1st February to 30th June. In the same year, the waste examination was recorded each week. The final stage was a questionnaire to some participants (faculty, staff, and students) to investigate staff reluctance to be involved actively in solid waste sorting and motivate more university staff to participate in waste sorting at the source. The results show that the separated solid waste material represented only 35% of the department's total generated waste through the research period. The total weight of the characterized waste was 448 Kg. Waste paper is the largest percentage of waste with a total weight (155.5 kg), followed by organic (110 kg), plastic (100 kg) and metal (82.5 kg). This research encouraged students to engage in reuse/recycle programs. They formed groups. The first group produced fuel oil from waste plastic by pyrolysis. The second student's group converted waste paper to card paper.

1. Introduction
Solid waste can be defined as a material that disposed of after use. It is unwanted substances produced because of human activities in different sectors, domestic, industrial, etc. [1]. Solid waste generation increased due to many factors, including the increase of the world population. The second factor is the new urban attitude, like the product covered by different packages that generate huge waste. Fast food is a clear example of waste accumulation. These accumulated waste mostly are non-degradable materials and made of plastics. [1]. Many countries are not aware of the importance and the purpose of solid waste sustainability despite the huge quantities presented to the environment, which cause severe problems [2].

Lifestyle changes lead to severe waste problems, waste plastic one of the biggest challenge facing the environment as there are many types of plastic used extremely and accumulated and disposed to landfill.

The accumulated solid waste either incinerated, recycled or dumped illegally. The increasing amount of solid wastes generated reduce landfill capacity. The authorities are also concerned about the impact of landfill operation and solid waste transportation [3].

The risk of unhealthy disposal of solid waste is important problems. This problem can be solved by adopting recycling and/or reuse plants. Solid waste recycles, and reuse programs can be effective
solutions if young people like students are carried on this solution and work to develop a new process or technology to provide future solutions to preserve the environment [4]. Because colleges and universities have the moral and ethical obligation to act responsibly towards the environment, they would be expected to be leaders in the movement for environmental protection. Specifically, it would be expected that universities would drive the efforts towards responsible waste management. Besides, adopting a sustainable program will benefit the institution by reducing the financial resources destined to waste management. Above all, it would set an example to the student's commitment to the community [5].

Student's awareness about environmental problems and solutions can be increased through education. It is expected that these solid waste management activities on the university campus involve the students as part of their learning process. The particular skills and knowledge gained from environmental education would help in changing human behaviour towards the environment. Students with some knowledge and skills in environmental education are more motivated to participate in environmental protection activities and plan, thus generate new ideas for environmental problems. Sharing new information from their families, other adults, and the community will probably have some positive implications on solid waste management practices. Although there are many kinds of literature on solid waste management regarding intergenerational influence and socialization processes, environmental education's practical impacts have somewhat been given little attention [1].

Despite the massive amount and complexity of waste produced, Iraq's waste management standards are still poor. These include outdated and poor documentation of waste generation rates and their composition, inefficient storage and collection systems, disposal of municipal wastes with toxic and hazardous waste, indiscriminate disposal or dumping of wastes and inefficient utilization of disposal site space. Litter at the roadside drains clogged up with rubbish and rivers filled with filthy garbage indicate that solid waste is a major environmental problem in Iraq. The audit outcomes of the research and the recommendations are to be fed back to the faculty, research unit members and students to prepare an action plan to be put in place to address the concerns raised, to ensure that the University community is working together towards achieving the waste strategy [6].

Iraq is a developed country that needs more focus on solid waste management programs to increase the attention to the solid waste accumulation problem in the society at different aspects, health, economic and environment. This study aimed to explain the main solid waste management's approaches to the students and faculty of the chemical engineering department - the University of Technology – Baghdad /Iraq to involved them to be a part of these approaches by participating in solid waste sorting at the sources and establish formal disposal procedures for all waste stream generated at the department. Encourage faculty and students to participate in recycling programs through different activities such as research in this discipline, create new ideas or technologies to improve waste reduction.

2. Methods
The study was conducted at the University of Technology. Chemical Engineering Department building – Baghdad – Iraq. The building is five floors consist of about 8 classrooms, 7 laboratories (for graduate and postgraduate), department administration, faculty rooms, library, service stores, etc. Total No. of the student is about 550, with faculty and staff more than 130 persons. The study was conducted at three stages. The first one, conduct seminars and discussions with the faculty and students to invite them to participate in the source sorting solid waste program at the department. The second stage estimated the total solid waste accumulated at each floor weekly, for one semester starts at 1st February till 30th June. In the same year (working days were five days Sunday to Tuesday), analyze the amounts and types of accumulated solid waste each week. The final stage was a questionnaire survey at the end of the research period to some participant faculty staff, and students. It is used to understand their opinion about the activity and encourage more members to participate in waste management program through source sorting or improving technology solid waste reduction.

The total questionnaire from distributed was about 115 they were distributed by hand to the department staff 36, which representative of 27% of the total staff. For the student, the total number of
surveyed student was 79, representative of 14% of the department's total students. The questionnaire is distributed in the last week of June. Usually, it returns to the researcher on the same day. It is believed that no official data recorded for solid generated at the chemical department building before the study.

3. Results and Discussions

The characterized waste represented only 35% of the total regenerated waste at the department during the research period. The total weight of the characterized waste was 448 Kg, as shown in Figure 1. The results saw the reason for the low waste segregation percentage 35%, due to weak knowledge of the importance of waste recycling and reuse at students and staff media. The generated waste can give a good start to the project capacity that faculty and students may start recycling or reusing the department's waste program.

Figure 2 shows the total characterized solid waste accumulates during the research period. The figure showed that paper is the largest percentage of waste with a total weight (155.5 kg) followed by organic (110 kg), plastic (100 kg) and metal (82.5 kg).

Figures 3a to 3d illustrate the waste accumulation during the research period (1st February to 1st June). The generated waste accumulation flocculates with time due to many factors, such as the examination period, where students spend less time at the campus than on a normal day. Other factors such as seasonal habits the second semester start in winter and finish at the beginning of summer.

Paper represent vital media for student and faculty it is part of their lecture, examination, report, etc. That is why the paper is the largest percentage among the other waste paper recycling can be a promising approach as shown in figure (3a), graduated students worked to recycled waste paper and converted to card papers. Organic waste reuse programs also can be started through anaerobic biodegradable to produce biogas to generate electricity as a pilot plant.

Total waste plastic accumulates about (100 kg) as shown in figure (3c). Based on this conclusion, reuse research for mixed waste plastics were done to extract oil waste [7]. The research concludes that the maximum liquid products yield from mixed waste plastic (Polystyrene(PS), and Polyethylene terephthalate(PET)) at optimum temperature (450 C), and heating time (90 min) was 77%, 67.56%, 54% and 37.48% by weight for the mixed plastic at different composition (100%PS,90% (PS)+ 10% (PET), 80% PS + 20% PET, 70%PS+ 30% PET) respectively. The liquid produced were characterized by GC-MS at optimum condition. The liquid component is styrene monomer, toluene, alpha-methyl styrene, 1,3 Diphenyl-propane, 1-Phenyl-naphthalene, 4-phenyl-1 butene. Styrene monomer was found to be the main product in the pyrolysis of 100%PS. The increasing concentration of aromatics (C_{12-C_{24}}) is due to the increasing polyethylene terephthalate percentage of many new oxygenated hydrocarbons. Besides the above research, students were interested in waste plastic pyrolysis. So they select the waste plastic pyrolysis as a graduate project using different plastic types (polystyrene and polypropylene). The produced oil was fractionated to different fuel cuts and test cuts specifications (density, viscosity, etc.). Thermal pyrolysis of waste polyethylene produced about 55% liquid oil. The produced oil was fractionated to different cuts, and the table below summarized the fractionate cuts.

| Fraction | TBP (C) | Weight (gm) | Yield % | API |
|----------|---------|-------------|---------|-----|
| 1        | 38-90   | 35.7        | 6.54    | 70  |
| 2        | 90-150  | 88.54       | 16.22   | 55  |
| 3        | 150-270 | 88.96       | 16.3    | 49  |
| 4        | 270-330 | 232.37      | 42.56   | 47  |
| Residue  | 330     | 56.5        | 10.3    | ----|

Figure (3d) shows the accumulated metal waste during the research study, and metal waste must be included in recycling/reuse programs by faculty or student's activities, design project or researches. The research includes a questionnaire to improve characterization at the source. Figures (4a and 4b) show the percentage of faculty and students involved in the questionnaire. Faculty represented about
(31%) of the total number, were students (69%). The percentage of female and male engaged in the questionnaire was (55%) and (45%) respectively.

Figures (5a and 5b) explained the university society opinion for waste characterization at source besides their ideas for initiating recycling/reuse programs and developing these programs.

In general, most participants agree and support waste characterization, but they asked for more lectures, workshops, and seminars for waste reuse/recycling. This step must be taken by a faculty member (who concern with reuse / recycle) to initiate their education programs. Figure (5b) shows that one impediment to characterize waste is the location and size of used bins for research participants to be involved in waste characteristic at the source. The location and size of used bins must be taken re-locate bins existence and change bins size.

Figure 1: Represents total solid waste generated, characterized and non-characterized during the research period.

Figure 2: The total characterized solid waste types accumulate from 1st February to 30th June.
Figure 3: (a) The total paper waste accumulates during the research period. (b) The total organic waste accumulates during the research period. (c) The total plastic waste accumulates during the research period. (d) The total metal waste accumulates during the research period.

Figure 4: (a) Total No. of a participant in the questionnaire. (b) The questionnaire participant gender.
(a)

(b)
Figure 5: (a) Participant opinions about source waste characterization at the department. (b) Factors effects on source waste characterizations at the department.

4. Conclusions

- The results show that the characterized waste was represented only 35% of the total regenerated waste at the department during the research period.
- Waste paper is the largest percentage of waste with a total weight (155.5 kg), followed by organic (110 kg), plastic (100 kg) and metal (82.5 kg).
- The research includes a questionnaire to improve characterization at source, the percentage of faculty and students involved as follow faculty represent about (31%) where student's percentage was (69%) the female and male involved at the questionnaire was (55%) and (45%) respectively.
- In general, most of the participants mentions that there lacks in department curriculum to the sustainable environment concepts, so they asked for more lectures, workshop, and seminar for waste reuse/ recycle
- The research led students to recognize the importance of solid waste management (reuse/recycling) programs. Thus, they contributed to this program through projects to reuse waste papers for card paper productions and produced fuel oil from waste plastic by pyrolysis.

5. Recommendations

- Waste source characterization attitude at the University campus required increase seminars and workshops to explain the necessity of waste segregations.
- Waste source characterization program needs to implement at another department on the university to include different student branches and departments.
- More research and feasibility studies must cover all recycling and reusing areas by faculty and students.
- Encourage students to create and innovate plants to recycle and reuse waste or develop new techniques. It is maybe part of industrial/private sector engagement.

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