Household composting in North Syria case study

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Abstract. The purpose of this study (Technical Assessment) is to recognize how to convert solid waste materials into composting in North Syria. Non-State Armed Group (NSAG) controlled areas, and indicates the produced mass of the compost per capita, the assessment showed that: the weather condition in the north of Syria is suitable for converting the domestic solid waste into compost within 99-111 days at the temperature: 10–35°C. The volume of the compost is about: 49.3%–55.2% of the volume of the solid waste before composting, that means the composting by housed hold could minimize the volume of solid waste to 44.8%–50.7% so the environment pollution of the and cost of dealing with the solid waste will be low, in general, the loss of mass and volume will have occurred during the composting process. The productivity of compost of each family is about: 0.69 – 0.8 kg/day and the production per capita is 0.08-0.129 kg/day, and the density of the compost 851.6–933.8 kg/m³. Only 6% of people who are involved in the questionnaire in Aleppo and Idleb governorates have no access to farmland whereas 94% of people have access to the farms and about 75% of people who have access to the farmland use fertilization. 92.35% of the interviewees reported that they are not familiar with the processes of converting the domestic solid waste into compost, whereas 7.65% reported that they are familiar with the composting process, and 57.1% of them reported that they were interested to convert the solid waste into compost and 42.9% of them expressed that they were not interest of composting; data shows the reasons why people were not interested in converting the solid waste into compost: 13.3% do not have the composting tools, 67.2% are not familiar with composting processes, 12.8% do not need compost and 6.7% of people need a long time to perform the composting.

Keywords: household composting, the Syrian crisis, solid waste.

1. Introduction
Solid Waste Management (SWM) as a result of approaches and practices that are used in different countries there are differences, particularly between developed and developing countries [1]. Solid wastes are any non-liquid wastes that result from human and/or animal activities and are discarded as useless or unwanted [2]. A lot of countries have realized that the way they manage their solid waste materials does not satisfy the goals of sustainable development in the world [3], [4]. In developing countries, a huge volume of solid waste disposed to the environment, so the solid waste management (SWM) is considered one of the critical problems [5].

The pollution of the environment has affected the human world since early times and is still growing due to excessive growth in developing countries [6]. Municipal solid waste (MSW) normally is a product of human activities [7]. Though SWM is one of the compulsory functions for improvement of urban lifestyle [8], an integrated SWM is one of the critical challenges for sustainable development [9]. In developing countries, the domestic solid waste contains important amount (50%) of biodegradable wet solid waste which could release undesirable odorous [10], One of the important challenging difficulties in the field of solid waste management especially in developing cities is the lack of current and detailed data [11]. Composting is the method most commonly applied worldwide for the recovery of the source of elements of organic waste because of its easy conduction and management [12]. Composting is an effective process for the valorisation of kitchen waste into a stable and nutrient-enrich biofertilizer [13]. Studies analysing the most environmentally friendly waste management methods had considered the home composting of the technologies with the best environmental impact [14]. The reduction of volume, mass waste, and producing compost for agricultural soil are considered the main advantage of
composting [15]. Many factors can affect the emissions of NH$_3$ gas during the composting processes such as: pH, temperature, humidity, type and properties of organic wastes, microorganisms, and aeration/mixing [16]. Many factors influence composting yields [17], such as the initial C/N ratio, pH, the oxygen supply, the initial C/N ratio of 20-40 is recommended for composting of wet solid waste [18]. The change in pH during the composting can also result in metals solubilization in leachate [19], the oxygen supply is important to ensure the optimal microbial activity. Emissions of NH$_3$, N$_2$O, CH$_4$, and volatile organic compounds are significant environmental concerns of the composting processes [20]. The gases emitted from the composting process vary, and are related to the initial materials composted and the applied methodology for composting processes (Ruggieri et al. 2009).

The composting could be conducted in types based on the locations, so it could be conducted in house or central place. the household composting requires low operation cost, and easy handling [21]. It could be conducted in the domestic gardens and it has many advantages over central, commercial, compost preparation facilities such as: nutrient cycles are closed [22]. For composting based on household, the householders should realize the role of the composter and which materials could be disposed of in it, for example, in the United Kingdom, householders were sold 0.3m$^3$ tanks to be used as composter and they had been given guidelines for using it in a good manner [23]. For achieving a successful program, it must be well designed, managed, also the program operators will plan to obtain the necessary planning.

In North Syria, the local councils conduct solid waste management, these local councils face many challenges when they work, due to lack of the financial resources, the main resource of their fund grants from Non-government organizations (NGOs) [24]. The municipality of each community is responsible for SWM, the solid waste collection (SWC) method was assessed in 2018 by the collaborative effort of the whole of Syria Coordination team (WOS), water, sanitation, and hygiene (WASH) partners, From Syria, Turkey, Jordan, Iraq and Lebanon Humanitarian Hubs [25]. In Syria, now, the Solid waste collection methods are conducted in many ways as the following:

- Household solid wastes are disposed to a dumping site: in this method, the householders transfer the solid waste by trucks (mostly a tractor with trailer due to the lack of compressed waste trucks) to the dumping site, this method came out after 2011 in the north of Syria especially at communities that are not served by governmental solid waste collection.
- Solid waste left in public areas: in this method, the people throw the solid wastes in public areas such as streets, and public areas because individuals and/or local councils do not have the ability to transfer the solid waste to the dump sites. This method also came out in the north of Syria after 2011, where the people became under poverty and the local councils do not have enough resources for conducting solid waste management.
- Free public solid waste collection: in this method, each local council in each community conduct solid waste management without receiving any fees from the served people. These local councils mostly are supported by NGOs.
- Paid private garbage the collection: in this method, the local council of each community conduct solid waste management and taking fees from the served people due to the lack of support.
- Garbage buried or burned: in this method, the people burn or bury the solid waste. This method also came out after Syrian crisis because the people and the local councils do not have enough resources for conducting solid waste management.

The table (1) showed collection methods and their percentage for Dana and Daret Azza subdistricts where the research was conducted [25].

| Subdistrict | Solid wastes are disposed by households to a dumping site (%) | Solid waste left in public areas (%) | Free public solid waste collection (%) | Paid private garbage the collection (%) | Garbage buried or burned (%) |
|-------------|-------------------------------------------------------------|--------------------------------------|----------------------------------------|-----------------------------------------|-----------------------------|
| Dana        | 0                                                           | 0                                    | 98.98                                  | 1.02                                    | 1.02                        |
| Daret Azza  | 1.05                                                         | 5.26                                 | 54.74                                  | 10.53                                   | 29.47                       |
Household composting in North Syria could be achieved and succeeded because the climate conditions are suitable, and also because there is a large component of organic materials so it could be a resource for producing a compost as an example is MSW of Aleppo city which contains 58% organic matters [26]. The household composting projects are very suitable in North of Syria due to the availability of domestic gardens and agricultural lands that need soil conditioners (North Syria is considered as an agricultural lands), as well as the lack of supported municipalities and companies which could conduct a central composting of the waste.

The author hopes of this research:
- Verify of the ability to convert the domestic solid waste to compost-based household in North Syria.
- Determine the expected amount and the volume of the compost which could be produced by a household.
- Study of people accept of the topic of converting solid waste into soil conditioners.
- Verify of the way cause of composting in Syria.
- Assess the abilities of the communities to convert the solid waste into compost and take a deep idea about the solid waste condition in the targeted communities.

North Syria suffers from solid waste accumulation problems and lack of treatment, as it is often left in public places due to the lack of financial capabilities of the local councils to collect and treat it, so the authors hope that household composting of the solid waste will be one of the important solutions to the solid waste accumulation problems in Syria and this research could be considered a first step in this field in North Syria, and, its results could be used to start small and medium projects related the household composting.

2. Methods
The current study was carried out in Dana Sub-district, which is located in Idleb governorate, and also in Daret Azza Sub-district, which is located in Aleppo governorate as in Figure 1 and 2, are controlled by Non-state armed groups since 2013. the number of the population of Deir Saman is 4199, and Tal Elkaramej is 19917. The author and the team of Syrian Engineers for Construction and Development (SECD) organization, which is registered in Turkey and works inside both Turkey and Syria, conducted field experiments about converting the solid wastes to compost. As a sample, three households of both Deir saman and Tal Elkaramej communities were selected to convert the domestic solid waste into compost and gender segregation of each family shown in table 2. Only organic solid wastes were considered for composting while the non-organic wastes were separated by the householders. As for the remnants of food, vegetable peels, fruits, and other organic materials, the people dispose them as a solid waste, and this is the organic waste on which the study of converting household waste into soil conditioners was conducted.

Also, SECD team conducted a filed questionnaire in the target locations using Kobo Toolbox (the questionnaire is attached), to assess the abilities of the communities to covert the solid waste into compost and take a deep idea about the solid waste condition in the targeted communities, 133 householders (HHs) samples were interviewed: 64 HHs of Deir Saman (48.12%), and 69 HHs of Tal Elkaramej (51.88%). The reference [27] was used for determining the size of the sample. The confidence level need was 95%, the margin of error was been accepted is 5%, also the response distribution was 50.

In terms of the numbers, we selected above, the sample size (n) and margin of error (E) are given by this Equation:

\[
X = Z \left( \frac{C}{100} \right)^2 r(100 - r) \\
n = \frac{N \times x}{((N - 1)E^2 + x)} \\
E = \sqrt{\left( \frac{(N - n) \times x}{n(N - 1)} \right)}
\]
where \((N)\) is the population size, \(r\) is the fraction of responses that we are interested in, and \(Z(c/100)\) is the critical value for the confidence level \(c\). The householders were: 28 female (21%) and 105 males (79%), and 46.5% IDPs, 53.5 HHs residents as shown below:

**Figure 1.** The targeted locations

**Figure 2.** Deir Saman, and Tal Elkaramej communities
Table 2. The selected households gender segregation.

| Family | Community | Governorate | Men | Women | Girls < 18 | Boys < 18 | Total |
|--------|-----------|-------------|-----|-------|------------|----------|-------|
| 1      | Deir saman| Aleppo      | 1   | 1     | 2          | 2        | 6     |
| 2      | Deir saman| Aleppo      | 1   | 1     | 4          | 2        | 8     |
| 3      | Tal Elkarameh| Idlib         | 3   | 3     | 2          | 2        | 8     |

Each family received 3 plastic bins of dimension: height: 67 cm, diameter: 32.5 cm, the plastic waste bins were used to make a recycle for the plastic and encourage this method. The bins were punctured with holes where the distance between each row is 10cm, and the distance between holes is 10 cm width, 10 cm height and the diameter of each hole is 14 mm, as shown in figure 4. These holes allow the air to enter to the bins and aerobic composting of the solid waste in order to decomposition of organic matter by aerobic microorganisms that need oxygen which found in the air, these aerobic microorganisms live in moisture around the organic matter. On other hand the harmful bacteria and pathogens will be killed by the heat which result from the aerobic composting. The domestic solid waste materials were filled by the householders in the early morning and the three bins were filled with only organic waste from start to finish each bin takes only 33-37 days for filling so the three bins take about 99-111 days for the filling, The three bins were filled in respectively so that the first bin is filled, then the second and the third one, after the completion of the third one filling, the 99-111 days have passed and the compost has matured and can be used in garden, In household composting methodology: biodegradable solid waste originated by families is used to yield compost for using it by the families or in near the location of the targeted household [23].
3. Results and Discussion

3.1. Compost Production

The technical assessments were conducted by the author and SECD team from January until May 2020. The results of the assessment are shown in table 3, also the figure 5: Showed some pics during the composting process by the householders, and figure 6 showed the compost after 3 months of the first day of starting the filling. The ratio of nitrogen to carbon was not rated because there is not a specified laboratory for doing these tests in the north of Syria. The present study demonstrated the production of quality compost in a fair duration.

Table 3. The result of solid waste composting.

| Sample | community     | The height of the waste in the first bin after 3 months (cm) | The duration of the filling of the first sample (days) | The weight of the compost in the one plastic bin after 3 months (Kg) | The productivity of compost household (kg/day) | The productivity of compost Person (kg/day) | The density of the compost (kg/m³) |
|--------|---------------|------------------------------------------------|-----------------------------------------------------|------------------------------------------------------------------|---------------------------------------------|-----------------------------------------|-----------------------------------|
| 1      | Deir Saman (1) | 33                                          | 31                                                  | 23.3                                                            | 0.78                                        | 0.129                                   | 851.6|
| 2      | Deir Saman (2) | 37                                          | 38                                                  | 26.4                                                            | 0.69                                        | 0.09                                    | 860.5|
| 3      | Tal Elkaramej  | 35                                          | 34                                                  | 27.1                                                            | 0.80                                        | 0.08                                    | 933.8|

There are some physical indications that the domestic solid waste became a good compost; it was dark brown, fine particles with no sign of original waste or big bits, smells earthy, the fluid and moisture is low. Also, some farming soil and leaves were to the organic solid waste for reducing the expected bad odours its percentage 10-15%. The volume of the compost is about: 49.3%-55.2% of the volume of the solid waste before composting, that means the composting by household could minimize the volume of solid waste to 44.8%-50.7% so the environment pollution of the cost of dealing with the solid waste will be low. In general, the loss of mass and volume will have occurred during the composting process. The same value was investigated by [28]. The productivity of compost of each household is about: 0.69 - 0.8 kg/day and the production per capita is 0.08-0.129 kg/day, and the density of the compost 851.6-933.8 kg/m³, approximately value has been investigated by [23].
3.2. Descriptive statistical analysis

The filled questionnaire that was conducted to assess the abilities of the communities to convert the solid waste into compost and take a deep idea about the solid waste condition in Deir Samaan and Tal Elkramej communities showed the following:

Only 6% of people who involved in the questionnaire of Deir Samaan and Tal Elkramej communities have no access to farmland whereas 94% of the people have access to the farm and about 75% of the people who have access to the farmland use fertilizer, and 23% of the interviewed people said that they
do not have solid waste bins in their households, 77% of them have solid waste bins in their households, and 67% of them use basket bins and 33% use plastic bags. 65.8% of the interviewed people made a separation of solid waste materials based on the household, and 34.2% of them did not conduct any separation, the type of the separated solid waste materials were batteries and electrics: 10.7% and also other materials such as: glass: 40%, metal: 13.3%, paper: 5.3%, plastic: 22.7%, texture: 8%, waste and materials that were separated from organic materials were sold and part of them as papers are used in heating in homes. About 92% of them said they sell it, and 5.3% recycle it, %2.7 random or throw it as showed in figure 7. Regarding the people who do not separate the solid waste, they do not separate the solid waste because 30.8% have not enough recyclable materials, 5.1% lack of awareness, 28.2 do not have time, and 35.9% not interested as showed in figure 8. The organic materials which is not separated by the householders were used for composting.

![Figure 7. The type of the separated solid waste materials by the household.](image)

92.35% of the interviewees reported that they are not familiar with the processes of converting the domestic solid waste into compost, whereas 7.65% reported that they are familiar with the composting process, and 57.1% of them reported that they were interested to convert the solid waste into compost and 42.9% of them expressed that they were not interest of composting; data shows the reasons why people did not interested in: 13.3% don’t have the composting tools, 67.2% they do not familiar of

![Figure 8. The reasons why people do not separate solid waste.](image)
composting processes, 12.8% don't need compost and 6.7% of people that the composting need a long time as shown in figure 10. The author wants to know if supporting the people with a small amount of money will make the people more interesting of composting processes based upon households, so the interviewed people were asked: if they would support with 10-20$ monthly, 92.1% said yes, they will do composting, whereas 7.9% said no, as in figure 11.

86.84% of the interviewed people assured that the public solid waste management is available in their neighbourhoods, 13.16 of them said there are not, 26.6% deposed it in open area, 40%, burn it and 20% bury it. About 78.9% out of 86.84% the interviewed people, who have access to the SWM, were satisfied with waste collection, 7.9% was not satisfied, and 13.2% did not answer the question, the solid waste collection frequency: (SWCF) Once a week: 6.1%, Twice a week: 71.9%, Three times a week: 3.5%, daily 5.3% and 13.2% did not give any answer, the SWCF once a week or twice a week are considered too low, it must be at least two times a week in the crisis [29].
Figure 11. The percentage of people who said they will be interested in converting solid waste to compost if they were given 10-20$ monthly.

4. Conclusion
Many developing countries suffer from the solid waste pollution and accumulation problems, including Syria. Applying the household composting for the domestic solid waste method will save the costs of solid waste collection, transferring and disposal. It will protect the environment and improve agricultural soil properties, household composting on the solid could be achieved and succeeded due to the climatic conditions that are appropriate, the availability of the domestic gardens, the high content of organic materials in solid wastes and popular acceptance, and field experiments have proven the possibility of converting household organic waste into compost within 99-111 days, and also interviews and questionnaires have shown the existence of a popular demand for that. But it is necessary at the beginning of applying this method to support people with the necessary equipment and conduct the necessary training. People in Northern Syria do not know how to convert organic waste into soil conditioners.

It is highly recommended to establish general management of solid waste in North Syria to achieve the best service of SWM and use the available resources in a good way and take a benefit of the studies which related to the developing countries to convert solid waste into compost. It is very useful in countries experiencing a humanitarian crisis such as Syria for the United Nations institutions and clusters such as: Water, Sanitation, and Hygiene (WASH), Early recovery (ER), and Food security and livelihood (FSL) encourage the NGOs to conduct a pilot project about the composting to reduce the pollution of solid waste and use the cash for work activities for encouraging the communities to convert the solid waste into compost and use the compost for improving the characteristics of the farms soil in Syria. The researcher hopes that more detailed research will be conducted with higher quantity and quality of compost that can be produced in households in the north of Syria, and to benefit from international research to reduce compost production time and improve its quality.

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