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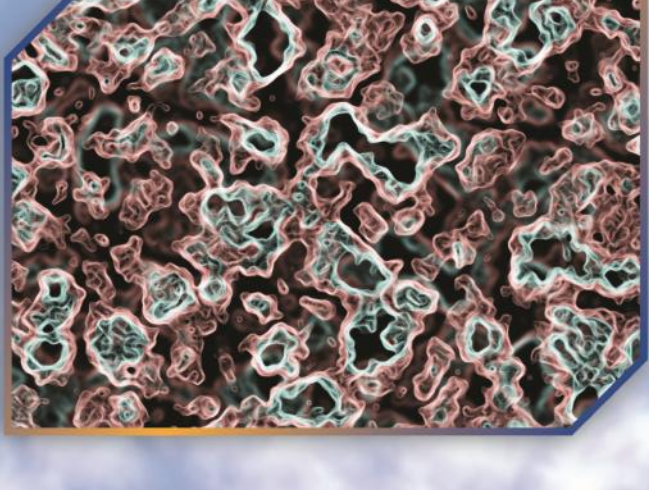

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CONFERENCE PAPER

Fast pyrolysis of biomass mixtures in a fixed bed reactor: Characterization of bio-oil product

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ABSTRACT

In this work, pyrolysis was carried out at 650 °C for 1 hour under an inert nitrogen atmosphere in a fixed bed reactor to determine the bio-energy potential of the chicken manure. The thermal decomposition of chicken manure was investigated by a thermogravimetric analysis technique. Ultimate analysis, FT-TIR and ED-XRF techniques were used to characterize the raw materials. Techniques such as FT-IR and GC-FID have been used to characterize the liquid bio-oil product produced by pyrolysis of chicken manure.

Keywords: Chicken manure, pyrolysis, fixed bed reactor, TGA, GC-FID

1. INTRODUCTION

The energy crisis is one of the most important problems today due to the increasing population [1]. In recent years, many scientists have searched for alternative energy sources [2]. Clean and stable energy supply has been demanded and desired in this context. Fossil energy sources such as coal, oil and natural gas have been gradually depleted over the past few decades, contributing to the development of clean energy sources such as solar, geothermal and biomass [3]. In the last 30 years, most researchers have focused on biomass energy (56%), which is a renewable energy source. Other energy sources include solar energy (26%), wind energy (11%), geothermal energy (5%) and hydroelectric (2%) energy [4]. Biomass is the world's fourth-largest energy source [5].

Biomass, because of its abundant supply and low life-cycle carbon emissions, is an important energy source [6]. Biomass resources such as dedicated energy crops, agricultural residues, forestry residues, aquatic plants, animal wastes, municipal solid wastes and poultry litter, are being investigated as potential resources for fuels and chemicals [7]. Chicken manure wastes, which are among the biomass resources, are a type of biomass with significant potential for use in the energy industry [8]. Turkey is the world's fourth largest poultry exporter. It is reported that the number of chickens is 266 million in 2013. Poultry in Turkey produce approximately 70 kg of waste per year per animal [9, 11]. Therefore, as a result of breeding poultry a large amount of poultry waste expose in Turkey and evaluation or disposal of these wastes creates a significant problem. Poultry farm waste entering the animal waste category is an ideal candidate for energy production due to the high yield of biomass production [9,10]. Biomass is one form of renewable energy source used for both heat and power generation through thermochemical and bio-chemical conversion processes like combustion, gasification, pyrolysis [11]. One of the transformation processes applied to biomass species is the pyrolysis process in which the materials are degraded thermally in an oxygen-free environment. Particularly biomass pyrolysis technology produces bio-oil, carbon-rich solid (bio-char) and hydrocarbons rich gas (bio-gas) products [12, 21]. Pyrolysis process is divided into three groups as slow, fast and flash pyrolysis depending on working conditions (retention time, heating rate, temperature etc.). In the fast pyrolysis method, biomass is converted to fuel at a very high heating rate (10-1000 °C s^{-1}) and in a short time (0.5-2 s) [21].

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In this study, the fast pyrolysis of chicken manure was carried out in a fixed bed reactor at a temperature of 650 °C, a heating rate of 20 °C min^{-1} for a 1 hour reaction time. Operating conditions (1 hour, 20 °C min^{-1}, 650 °C) were determined according to the fast pyrolysis conditions. Characterization of the raw chicken manure (CM) was performed by ultimate analysis (C, H, N, S and O analysis), FT-IR analysis, Thermogravimetric analysis, ED-XRF analysis (Energy Separated X-Ray Fluorescence Spectrometer). Characterization of the liquid product obtained after pyrolysis was performed using FT-IR analysis and GC-FID analysis.

2. MATERIALS & METHOD

2.1. Material and characterization

The chicken manure (CM) sample was collected from Samsun city of Turkey. The sample was dried in a 70 °C oven overnight, crushed, and sieved to a particle size of 60–120 µm. Ultimate analysis (%C, H, N, and S) was performed with a CHNS-932 LECO brand analyzer. For XRF (X-ray-fluorescence) analysis, CM sample were dried in an incubator and then grounded in spex mill. The obtained powder was sieved using a 140 mesh sieve and then stirred for 25 min. Then, sample was pressed into 40 mm diameter pellets. The measurement parameters were set up by using the Epsilon 5 EDXRF system's inbuilt software. Sample was irradiated by X-rays from Gd tube under a vacuum equipped with a liquid nitrogen cooled PAN-32 Ge X-ray detector having been window thickness of 8 µm.

2.2. Thermogravimetric Analysis

Thermogravimetric analysis of CM was performed by a thermogravimetric analyzer (TG-DMAQ800) at heating rates of 20 °C min^{-1} under a N_2 atmosphere with a flow rate of 100 mL min^{-1} with sample of approximately 5 mg.

2.3. GC-FID Analysis

Analysis of the examined bio-oil product was performed on a gas chromatography–mass spectrometry (Shimadzu, GC-2010Plus) using FID detector. The GC separation of pyrolysis vapors was performed with a 30 m×0.25 mm×0.25 µm RTX-5 column from Agilent with helium carrier gas flow of 1 mL min^{-1}. The GC inlet was at 270 °C, and a split ratio of 20:1 was used. The oven was programmed to start at 50 °C. It was held at 50 °C for 4 min and then heated at 5 °C min^{-1} to a final temperature of 270 °C and kept for 7 min.

2.4. FTIR Spectroscopy

The FTIR spectrum of the raw CM and bio-oil was recorded on a FTIR spectrometer (Perkin Elmer, Spectrum Two, ABD) in the range of 4000-600 cm^{-1}. ATR was used for all measurements.

2.5. Pyrolysis Experiment

The pyrolysis of CM (10 g) was carried out in the fixed bed reactor. The pyrolysis experiment was conducted by nitrogen gas a flow rate of 100 mL min^{-1} at 650 °C and 20 °C min^{-1}. The reactor temperature was checked with a thermocouple placed inside the reactor. The pyrolysis experiment took about 60 minutes. The liquid product obtained at the end of the pyrolysis experiment was collected in the dichloromethane solvent. The solvent was then separated from the bio-oil using a rotary evaporator.

3. RESULTS & DISCUSSION

3.1. Characterization of CM

The chicken manure was characterized by using ultimate analyses, and calorific analyses the experimental results are submitted in Table 1. As shown in this table, the carbon values of mixtures are 23.17%. Chicken manure has high nitrogen content due to the presence of proteins and amino acids in the sample, as it is in mixture with feed, wood and other biomass species. In general, the nitrogen value of chicken manure varies between 2.50 and 4.25% in the literature [13].

The nitrogen content of the CM is higher than the literature results. The sulfur value of CM (0.48%) is lower than the literature results [14]. When the elemental analysis results are compared with the literature, blends of chicken manure can be evaluated for the wastes during pyrolysis process.

Table 1. Ultimate Analysis of raw CM

Ultimate analysis (wt.%)	CM
C	23.17
H	5.81
N	4.58
S	0.48
Oa	65.96
Calorific value (MJ kg^{-1}) [8]	12.74

The composition of raw chicken manure is shown in Table 2. Table 2 shows that the content of Ca element is 22.85%. P, K and Ca raw chicken manure are also the main compounds. Studies in the literature have shown that poultry wastes contain high levels of Ca and K [13].

Table 2. Compositions of CM (%wt)

Sample	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	Fe_2O_3	Others
CM	6.10	4.30	13.04	22.10	6.51	20.96	22.85	2.19	1.95

The FTIR spectrum of raw Chicken manure is present in Fig 1. The large peak at 3317 cm_{-1} is attributed to the stretching of primarily O-H groups. The symmetric and asymmetric stretching vibration associated with the peak at 2972 cm_{-1} of C single bond H are alkyl and aliphatic chains. The stretch of C=O in FTIR spectrum of raw CM is 1651 cm_{-1}. Moreover, the C=O group is mainly from the acids, aldehydes and ketones [15].

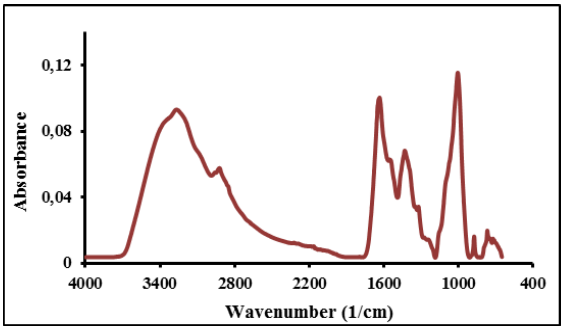

Fig 1. FTIR Spectrum of CM

3.2. *Thermogravimetric Analysis*

The results of thermogravimetric analysis (TG) and differential thermogravimetric analysis (DTG) of chicken manure at a heating rate of 20 °C min^{-1} are given in Fig 2.

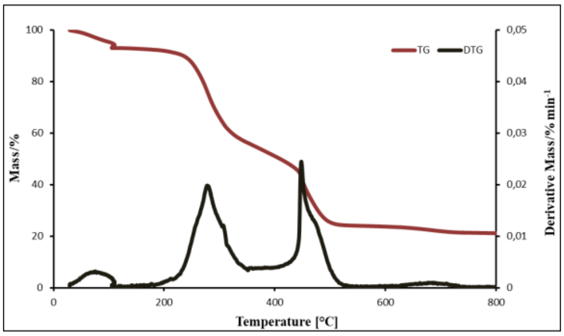

Fig 2. TG-DTG curves of CM

Therogravimetry (TG) and differential thermogravimetric analysis (DTG) curves were used to determine the mass loss steps of the chicken manure in the pyrolysis process. In pyrolysis or combustion reaction studies made with a TGA device, differential thermogravimetric analysis (DTG) curves give more precise results when determining the points at which the reaction reaches the start, end and maximum velocity. When we examine the DTG curve, a weight loss was observed at about 100-200 °C in chicken manure. At this stage, the moisture from the sample and the low molecular weight substances on the surface has disappeared. The main decomposition range of chicken manure was determined to be 200-560 °C from DTG curves.

3.3. *FT-IR spectrum of bio-oil*

The FTIR spectrum of the liquid product (bio-oil) obtained from the chicken manure pyrolysis are shown in Fig 3.

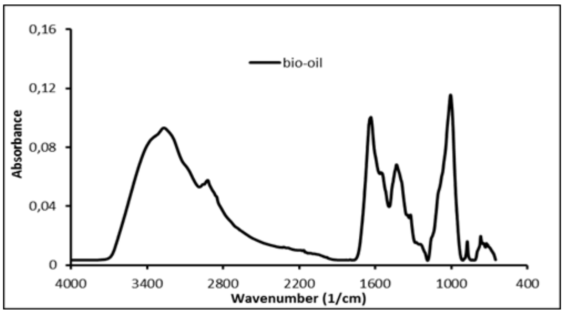

Fig 3. FTIR Spectrum of pyrolysis liquid product

When the FTIR spectrum of the pyrolysis liquid product is examined, the peak observed at 3000 cm^{-1} are the C-H stress vibrations of aliphatic hydrocarbons and wide vibration seen at 3281 cm^{-1} is the O-H stretching vibration. In the spectrum, the strong peak of the C=O asymmetric stretching vibration appears at 1650 cm^{-1}. This peak indicates that the compounds are acid, aldehyde and ketone groups. The peak observed at 1448 cm^{-1} shows the C-H bending vibration of the aliphatic hydrocarbons. It can be said that the peaks observed at about 1000-1500 cm^{-1} belong to the C-O, C-N and C-C stretching vibrations, and that these peak consist of compounds such as ether, alcohol and acid [16, 17].

Table 3. FTIR Analysis Results of CM

Functional group	Wavenumber (cm^{-1})	Species
	Raw CM	
O-H stretching	3317	H2O
C-H stretching	2972	Aliphatic hydrocarbons
C=O stretching	1651	Aldehydes, ketones, acids
C-H bending	1444	Aliphatic hydrocarbons
C-C,C-O,C-O-C stretching	1000-1500	Alcohols, phenols, ethers
	Bio-oil	
O-H stretching	3266	H2O
C-H stretching	2921	Aliphatic hydrocarbons
C=O stretching	1634	Aldehydes, ketones, acids
C-H bending	1431	Aliphatic hydrocarbons
C-C,C-O,C-O-C stretching	1000-1500	Alcohols, phenols, ethers

3.4. GC-FID Analysis

Pyrolysis of chicken manure was carried out in a fixed bed reactor at 650 °C. Gas Chromatograph-Flame Ionization Detector (FID) was used for the characterization of the resulting liquid product. The data in the literature have been used for the identification of the substances corresponding to the peaks observed in the chromatogram. The chromatogram showing the peaks corresponding to the different retention times of the pyrolysis product bio-oil is shown in Fig 4.

GC-FID analysis was performed to determine the organic compounds found in the structure of the liquid product obtained from the pyrolysis of CM. GC-FID chromotograms of the liquid product obtained as a result of the pyrolysis process at a temperature of 650 °C are shown in Figure 4 and the results are given in Table 4.

As shown in Fig 4, 15 peaks were determined on the chromotogram of the liquid product obtained as a result of pyrolysis of CM. Peaks with a total area of more than 1% were identified using the literature and the results in Table 4 were presented. The peak from the 3.36 retention time in the chromatogram has the largest (29.95%) largest area. The resulting liquid product (bio-oil) contains many different chemicals. Literature results suggest that this liquid product composition is composed of compounds containing furan, carboxylic acid and phenols in general [18, 19]. The bio-oil content obtained from pyrolysis from chicken manure in the literature consists of phenols, acids, N-containing compounds [20].

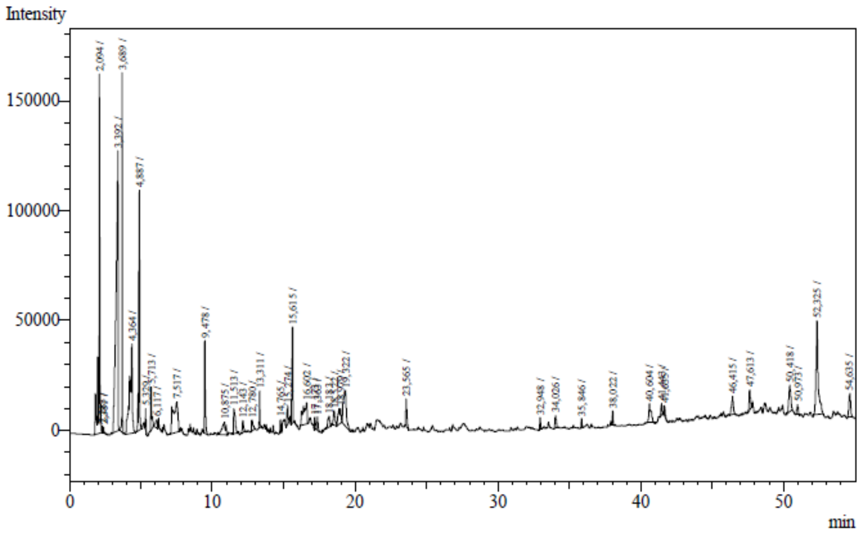

Fig 4. GC-FID chromatogram of bio-oil product obtained from pyrolysis of CM

Table 4. GC-FID Analysis Results of Bio-oil

Number	Retention time (min)	Area (%)
1	2.09	9.52
2	3.39	19.95
3	3.69	5.03
4	4.36	8.22
5	4.89	7.59
6	5.71	1.55
7	7.52	5.22
8	9.48	2.72
9	11.51	1.56
10	15.62	3.16
11	19.32	3.92
12	23.57	1.07
13	50.42	1.96
14	52.33	7.22
15	54.64	1.47

4. CONCLUSIONS

In this study, an important biomass source, chicken manure was pyrolysed in a fixed bed reactor at 650 °C for 1 hour during the reaction period. Characterization of the products obtained using ultimate analysis techniques for characterization of chicken manure was performed using FT-IR, GC-FID spectrum were taken. It can be regarded as fuel because it has both low pyrolysis temperature and pyrolysis product contains aliphatic and aromatic hydrocarbons compounds. As a result, in the case of waste in our country, high quality liquid product was obtained from chicken manure, which is one of the most important renewable energy sources in abundance.

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CONFERENCE PAPER

Economic analysis of biogas production from small scale anaerobic digestion systems for cattle manure

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ABSTRACT

One of the major concerns of biogas plants can't be operated economical and environmental sustainable manner. In order to produce biogas in rural areas, using anaerobic systems with high organic content of farm wastes can be able to remove these concerns. The production of biogas can then be used for cooking, lighting and heating. Biogas is a good alternative to kitchen gas cylinder. However, there is a lack of knowledge and experience available on design methods for these systems. Anaerobic digestion is generally economically applicable waste treatment systems for large farms (>100 cattle). However, majority of Turkey farms have less than 100 cattle, making this technology economically inaccessible to the vast majority farms. The objective of this study is to determine the economic viability of small scale anaerobic digester systems taking into account on domestic production conditions.

Keywords: Anaerobic systems, small-scale, biogas, economic analysis

1. INTRODUCTION

Especially in Turkey the establishment of biogas production facilities has generally implemented by foreign-based companies. This creates major problems both for the installation and operation of the biogas production system. There are a lot of studies about anaerobic biogas processes in Turkey and abroad. Local facilities need to be used in the construction of the biogas plant but cost-benefit analysis guide studies are not enough about on this issue.

Sustainable production is one of the most important factors for people's peace and well-being. A healthy environment is essential for continued sustainability and mobility of production. There are many natural resources in Turkey that can be used for human benefit. One of these natural sources is organic waste. In fact, it needs to be disposed of because it is waste. Therefore, biogas production systems are attractive due to useful outputs of anaerobic digestion such as waste disposal, biogas and organic fertilizer production.

Nowadays, it has become a necessity to increase the production volume together with population growth. Along with the increase in production, waste generation has also increased. Generally food products such as meat, meat products, milk and dairy products are considered for this system. An important part of this production area is large, medium and small scale cattle breeding farms. As a result of the increased need for these products in Turkey, the cattle breeding sector has shown a serious growth in recent years with the incentives of the state. According to data of Turkey Statistical Institute (TSI), the bovine animal number increased by 13.2% in 2017 when compared to the previous year and became 16,105,000 heads at the end of the year [1].

The livestock sector, in fact, is an important source of livelihood, but also a labor that requires considerable costs. Lowering costs in this sector is very important for manufacturers. Biogas production is a technology that can help reduce biogas production costs in the livestock sector. It is clear that the use of biogas plants, which have reached significant numbers in many countries such as Germany, Denmark, Italy,

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India, Pakistan and China, should also be widespread in Turkey. Particularly in rural areas and in villages where gas demand is supplied by kitchen gas cylinder is seen that there are many benefits in using animal wastes for biogas production. It is more feasible to use biogas instead of kitchen gas cylinder where natural gas is not used.

There is not much animal manure accumulation in sheep or goat livestock, especially since livestock farming is done in rural areas. But, there is a waste accumulation in cattle livestock because the animals are in the stall at night. For this reason, the selection of cattle manure (CM) as the majority of waste to be used in biogas plants will provide great convenience in terms of operation of the plant. However, the addition of wastes with higher organic load to CM has been found to have beneficial effects which is around 20% [2, 3]. Hereby, the organic wastes with higher organic load will be included in anaerobic process.

In this study, a biogas production system in order to carry out the joint treatment of CM with wastes containing high levels of organic matter and to obtain biogas and organic fertilizer as a result is taken as basis. The use of local industrial facilities in the biogas system has been prioritized. For this reason, the system that can contribute to the economy and the environment that the local people who are engaged in livestock production can implement has formed the framework of the cost analysis work.

2. METHODS

2.1. Small-Scale Digestion System Cost Analysis Study

In this study, it was considered to design a biogas plant to best provide anaerobic conditions. For this reason, fixed dome biogas plant was chosen as the model for the current conditions. It is aimed to use completely local facilities for installation of the biogas plant. It is thought that the plant will be built underground. It is planned to provide the necessary temperature values for anaerobic conditions by solar collectors. It is planned to construct the reactor body from metal materials and to make necessary insulations.

The sizing of the biogas plant has been based on the number of people who will benefit from the biogas to be produced. One person needs 0.34-0.42 m^3 of biogas to meet the need to cook daily meals [6]. The amount of biogas that each person would use for cooking daily was assumed to be 0.5 m^3 day^{-1}. According to this, benefit cost analysis was performed for 6 different reactors' volumes with biogas production capacity of 1, 2, 4, 8, 16 and 32 m^3 day^{-1}, which can be used by 2, 4, 8, 16, 32 and 64 people, respectively. It was also assumed that bovine animals would produce 10 kg of manure per day and reactors were sized according to 20-days hydraulic retention time (HRT). It is planned to make a water jacket around the reactor until half of the required volume for the purpose of temperature control in the biogas plant. Adiyaman city located at the south-east part of the Turkey was chosen as the plant installation place for the account of the necessary solar collectors. The biogas production value of wet CM was assumed to be 0.034 m^3 kg^{-1}. Total solid (TS) of the feed waste ratio was chosen as 5%. It is planned to add 2 - 2.5 L of tap water to 1 kg of CM that has an average TS of 16.67% to capture 5% TS ratio.

In the construction of biogas plants, for construction cost items as fixed cost items; stainless steel sheet, stainless pipe (Ø 10 cm), solar collector, thermostat, plastic pipe, water trap, other consumables were taken into consideration, in the labor items; the costs of pit digging and reactor construction were also considered. As operating cost components; maintenance and repair costs, electricity cost, water cost, labor cost and additional waste cost were foreseen. Water and labor costs in small-scale plants, including the 12 m^3 capacity reactor, are not included in the operating cost calculation. As of the end of 2017, the value of the biogas produced was calculated on the basis of the equivalent price of 12 kg of kitchen gas cylinder. The calculations are not included, such as the cost of animal manure, the gain obtained from the organic fertilizer, social and environmental benefits. The facilities have been tried to be designed as far as possible considering the conditions that can be supplied and operated in the local market. While some cost elements are easily and cheaply available, they have always been tried to stay within safe boundaries.

2.2. Model Selection for Planned Biogas Plant

Several different types of systems have been developed because biogas production and the use of biogas are based on very old ones. Designed facilities are classified according to structure and operating conditions. In fact, anaerobic conditions occur in the presence of an airless environment, an appropriate temperature and fattening medium.

The availability of technological possibilities is up to the point where the cost-benefit relation is optimal. Biogas plants that founded by importing are not preferred because their cost returns are very long. For this reason, the systems to be used for small, medium and large scale biogas plants in Turkey conditions should be able to be produced in the domestic industry. In this case, sustainable systems should be designed with benefit cost analyzes that can be carried out and operated by people engaged in animal husbandry.

The designed biogas generator should be particularly leak-proof and have a stable temperature. Also, as the amount of waste load increases, the mixing need also arises. For this reason, it is considered that the model which can best meet the above mentioned conditions is a fixed domed biogas plant model.

Fixed domed biogas plants are totally enclosed systems with no connection to the outside, except waste input-output and biogas output. When biogas exits from the system, biogas bubbles play an active role in mixing the system. The built-up biogas reactor increases the internal pressure as it accumulates in the upper part, and the reactor raises the mud in the inlet and outlet lines. This likewise helps to stir the reactor.

Due to the fact that it is not a mobile part of fixed domed biogas systems, it has a simple structure and installation cost is very low. When produced with a stainless steel material such as steel, it has a life span longer than 20 years. When the system is digged in the soil, it can be protected from physical external environment conditions and a more stable system can be formed by preventing temperature differences at night and day. If waste input and output are not connected to a mechanic device, waste feed is done by human power, so operating cost is considerably reduced.

There are different models of fixed domed biogas generators. The Chinese model is the first archetype of this model. The reactor consists of a cylindrical body. The Janata-type model is not currently used due to cracks and leakage problems in India. Deenbandhu model is more developed than Janata model and more resistant to cracking. CAMARTEC is a model developed in Tanzania in the 1980s [4].

Fixed domed biogas generators resistant to cold climates have known designs in the range of 5-200 m^3. These facilities, which can be easily done with local amenities and have a low installation cost, have been preferred systems with ease of temperature control. Gas leaks and low underground temperatures are important disadvantages of the system. The plant is designed with a metal body and it is considered that these problems can be avoided together with the necessary insulation when heating with solar energy. Nowadays fiberglass material can be produced at very low cost. However, in terms of longer reactor life, a metal body design would be more advantageous.

3. DESIGN OF BIOGAS PRODUCTION PLANT

Especially the amount of waste generated in the design of biogas plants is the most important design criterion. In recent years in Turkey, cattle livestock has become widespread with state incentives. Due to the lack of adequate pastures, especially cattle breeding is done more often in stables. At least the bovine animals in the stalls at night can produce enough fertilizer to operate the biogas plant. When cattle farming is carried out in the stable, there is no waste stagnation and CM to be treated are formed in considerable volumes.

If only the bovine animal feed is used in the planned reactor, the daily amount of manure, the feeding patterns of the animals and the solids content of the manure must be known. Daily amount of manure can vary depending on the type and age of the animals. Manure production can be accepted for cattle 10-20 kg day^{-1} (wet) or 5-6% of live weight can be used for daily manure production [5].

3.1. Required Waste Account

The biogas plant to be designed can be sized according to the amount of biogas produced per day. The biogas plant can be designed according to biogas needs or the amount of available CM. 0.04 m^3 biogas can be produced from 1 kg wet CM. According to this, 1 m^3 biogas can be produced 25 kg wet CM [6, 7]. The daily biogas consumption varies according to different uses and the daily biogas consumption required for cooking is 0.227 m^3 [8]. According to this, the number of people that could be benefited, the amount of CM needed and the number of bovine animals were shown in Table 1 according to the amount of biogas to be produced.

3.2. Reactors Volume Calculations

In order to anaerobically treatment wastes with high organic content, it is necessary to adjust the organic loading ratio with the addition of water. In this case, as the volume of waste increases, the cost of the processes such as heating, mixing, pH balancing, dewatering will increase as the reactor volume increases. Accordingly, the initial investment cost and operating cost will increase. For this reason, it is necessary to select a solid matter rate that CM and other additive wastes can easily be fed into the system and evacuated from the system. The rate of solid matter of the substrate fed to the biogas reactors was selected as 2.8% [9], 5% [10], 6.07% [11] and 6.7% [12] by some researchers. In the experimental study, the anaerobic sludge TS ratio in the reactors varied between 3% and 6% [13]. The approximate reactor volume according to the amount of biogas desired to be produced is given in Table 2.

Table 1. The amount of CM needed, the number of animals and the number of people to benefit from different designs

Biogas plant design no	Biogas capacity of plant (m^3 day^{-1})	The number of people who can benefit	The amount of CM needed (wet) (kg day^{-1})	The number of animals
1	1	2	29	3
2	2	4	59	6
3	4	8	118	12
4	8	16	235	24
5	16	32	471	47
6	32	64	941	94

Table 2. Required reactor volume calculated on the basis of biogas production for HRT of 20 days

Biogas capacity of plant (m^3 day^{-1})	The amount of CM needed (wet) (kg day^{-1})	Amount of water to be added (L day^{-1})	Feeding volume (L day^{-1})	Required reactor volume for feeding liquid (m^3)	Total volume with biogas collection section (m^3)
1	29	68	98	2	3
2	59	138	197	4	6
4	118	275	393	8	12
8	235	548	783	16	24
16	471	1099	1570	31	47
32	941	2196	3137	62	94

3.3. Initial investment cost (fixed cost)

In order to temperature control in the biogas plant, a water jacket with half of the volume of the biogas plant should be constructed around the reactor. Accordingly, the installation of the solar collector and the thermostat has been considered. The assumed biogas plant is shown in Figure 1.

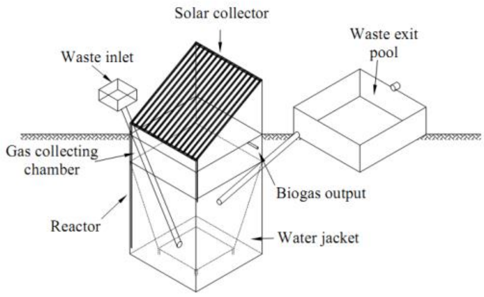

Figure 1. Considered Fixed Dome Biogas Plant with Solar Collector

The ratio between the volumes of the reactors considered is approximately 2 times. The increase coefficient of material to be used according to the volume increase was determined as about 1.6. For this reason, cost calculations were approximate calculations. Initial investment costs for biogas plants for different volumes are given in Table 3.

The parameters affecting the determination of the collector surface area depends on the time of utilization of the system, the amount of water to be heated, the inlet temperature of the water system and the temperature level. Biogas plant was planned to be installed in Adiyaman. It was desired to utilize the solar collector system year-round. For this reason, the most efficient collector angle (latitude x 0.9) for Adiyaman at 37.4 latitude was calculated as 33.66 for the whole year. In the calculation of the required collector surface area; the water temperature to be heated as to 38 °C, and the return water temperature was 34 °C. The amount of total solar irradiation (TSI) coming to the collector surface was calculated as 4328 (kcal m^{-2} day^{-1}). Collector yield was determined as 60% for the required collector area [14]. The collector costs required for different volumes are given in Table 3. The required collector surface area was considered by using the equations in the footnote of Table 3.

3.4. Annual Operating Cost

Maintenance costs for the plant, electricity costs for the control, labor costs for feeding the CM and additional waste costs may be added to the annual operating costs of the biogas plant. Water and labor costs have been neglected up to a volume of 24 m^3 reactor, since some of the water required for waste preparation in the biogas plant is considered to be supplied from the reactor effluent. It is seen that the Total Chemical Oxygen Demand (TCOD) values of the gram dry matter of the additional waste to be used are close to each other [13]. In terms of cost security, maize silage, which is a valuable animal feed that could be costly in Turkey, is considered as an additive material. Maize silage contains at least 30% dry matter [15] and according to the price statistics for 2018, 1 ton maize silage is 300 Turkish Liras (TL) [16]. The TS ratio of CM was determined to be 16.67% [13], which is about half of the maize silage TS ratio. It is considered that an operating cost to represent the additional cost of the waste at safe intervals is chosen. In the reactor with a volume of 24 m^3 and larger volumes, the feeding of the waste should be considered by using a pump. For this reason, electricity cost will increase in these reactors. Annual operating costs for the reactors considered are given in Table 4.

4. RESULTS & DISCUSSION

The need for cooking in the rural area is covered with liquefied petroleum gas (LPG) cooking gas cylinders. As of the end of 2017, the average price of 12 kg LPG cooking gas cylinder is approximately 92.5 TL [17]. 1 m^3 biogas equivalent to 0.43 kg LPG [6]. According to the calculations made, about 1 m^3 day^{-1} of biogas could be produced from about 3 cattle (10 kg CM day^{-1} cattle). When considered annually, about 157 kg of LPG (13 LPG cooking gas cylinder (12 kg)), will be produced as 365 m^3 of biogas equivalent. According to the calculations which were made the cost analysis, it was determined that in the planned biogas installations for 3, 6, 12, 24, 47 and 94 bovine animals, there will be a clear return of 5, 14, 31, 27, 90 and 218 LPG cooking gas cylinder per year, respectively. Table 5 provides cost-benefit calculations of biogas plants according to their capacities. In addition, when a biogas plant capable of being operated with high CM and organic wastes is installed, fermented fertilizer will be produced along with biogas with high calorific value. However, the financial value of the organic fertilizer formed at this stage has not been added to the cost calculations, since the CM is regarded as agricultural fertilizer in the unprocessed state in the sense of the farmers. In addition, it is an invisible gain that the environmental defects such as odor, fly, pathogenic microorganisms, water pollution and greenhouse effect which can be caused by these wastes have been eliminated.

Table 3. Initial investment costs for biogas plants for different volumes

Expenditure items		Cost of materials used according to biogas plant volume (TL)					
		$3\ m^3$	$6\ m^3$	$12\ m^3$	$24\ m^3$	$47\ m^3$	$94\ m^3$
A. Construction							
1.	Stainless sheet	1040	1840	2880	4150	6910	11520
2.	Stainless pipe (Ø 10 cm)	186	186	372	372	372	558
3.	Solar collector*	1200	1200	2400	4800	9600	19200
4.	Thermostat	272	272	272	272	272	272
5.	Plastic pipe	60	60	60	60	60	60
6.	Water trap	45	45	45	45	45	45
7.	Other consumables	120	132	145	160	176	193
8.	Painting	70	112	180	287	459	734
9.	Insulation	120	180	240	420	660	1020
Subtotal		3113	4027	6594	10566	18554	33602
B. Labor							
1.	Digging the pit	120	240	480	960	1920	3840
2.	Reactor construction	1200	1920	3072	4915	7864	12582
Subtotal		1320	2160	3552	5875	9784	16422
Total cost (A+B)		4433	6187	10146	16441	28338	50024

*$F_k = Q_{hot}\ (TSI\ \eta)^{-1}$ F_k: Collector surface (m^2), Q_{hot}=m c Δ_t : Hot water energy requirement (kcal day^{-1}), m: Amount of water to be heated (L day^{-1}), c: Water heating tem**p**erature (kcal kg^{-1} °C^{-1}), 1 can be taken., Δt: Difference between the desired water temperature and the water inlet temperature (°C), TSI: Amount of solar energy coming to the collector surface (kcal m^2.$gün^{-1}$), η: Collector yield (%). The average yield in collectors can be taken between 55-65%.

Table 4. Annual operating costs for reactors considered

	Cost component	Cost of operations to be performed according to biogas plant volume (TL)					
		$3\ m^3$	$6\ m^3$	$12\ m^3$	$24\ m^3$	$47\ m^3$	$94\ m^3$
1.	Maintenance and repair expenses (4%)	177	247	405	657	1133	2000
2.	Electricity costs	240	240	240	600	960	1680
3.	Water costs	-	-	-	416	815	1630
4.	Labor costs	-	-	-	2920	2920	2920
5.	Additional waste costs	318	646	1292	2573	5157	10304
	Total cost	735	1133	1937	7166	10985	18534

Moreover, the world has been particularly interested in the release of greenhouse gases in recent years. For this reason, anaerobic systems have a separate precaution for controlling greenhouse gas formation. It is known that when greenhouse gases are evaluated according to global warming potentials, CH_4 and N_2O are 23 and 296 times more greenhouse effect than CO_2, respectively [18]. As a result of the anaerobic treatment of the wastes, a 10% reduction in N_2O emissions can be achieved. Moreover, 1 m_3 of biogas is equivalent to 0.5 kg of petroleum, and CO_2 emissions are reduced by 2.6 kg when biogas is preferred instead of petroleum [19]. Barton et al. [20] assessed emissions of greenhouse gases on the assumption that waste with high organic load was treated with different treatment methods. According to this, 0.74 tons (CO_2 eq ton^{-1} waste) of greenhouse gas is formed when organic wastes are applied in the field. Whereas, in the case of anaerobic decay, they reported that the effect on greenhouse gas emissions was reduced by 0.21 tons (CO_2 eq ton^{-1} waste). In Turkey CM is generally applied to the land. If these wastes are treated in anaerobic systems without applying to the surface, greenhouse gas emissions will be reduced by (0.74 + 0.21) 0.85 tons CO_2 equivalents per ton of waste. According to this report, when the manure of 100 cattle is subjected to anaerobic decay, the greenhouse gas emissions will be reduced by the equivalent of (100 cattle x 3,65 tons wet manure year^{-1} cattle x 0.167 TS / wet manure x 0.85 tons CO_2 eq) 51.8 tons CO_2 equivalent per year.

Table 5. Benefit-cost calculations of biogas plants according to their capacities

Biogas plant capacity (m³)	Annual biogas production (m³)	LPG equivalent value of biogas (kg)	Biogas annual turnover (TL)	Initial installation cost of biogas plant (TL)	Annual operating cost of biogas plant (TL)	Annual net turnover of biogas plant (TL)	Biogas plant payback period (years)	Net profit over 20 years' (TL)
3	365	157	1210	4433	735	475	9.3	5067
6	730	314	2420	6187	1133	1287	4.8	19553
12	1460	628	4841	10146	1937	2904	3.5	47934
24	2920	1256	9682	16441	7166	2516	6.5	33879
47	5840	2511	19356	28338	10985	8371	3.4	136082
94	11680	5022	38711	50024	18534	20177	2.5	353516

The biogas that can be produced in the biogas plants planned to be established is calculated based on the equivalent LPG value. According to the annual turnover, 20 years of facilities' return and repayment period have been determined, assuming that the life of the plants is 20 years. As can be seen from Table 5, as the plant capacity increases, the payback period and net profit increase. In this study, all the possible costs were tried to be considered. As a result, fluctuations in net earnings are seen. The initial investment cost will be reduced when different materials except metal are used, especially in the construction of small plants. The income from the organic fertilizer produced in the same way is not included in the calculations. In addition, the environmental protection of the biogas plant to be installed should not be overlooked. This is an important indicator of the need for state support in such projects. When the necessary support is given to these investments, it is thought that the number of biogas plants will increase rapidly in Turkey.

5. CONCLUSIONS

When a general evaluation is made, about 1 m^3 of reactor volume is needed for each cow, and approximately 120 m^3 year^{-1} biogas production can be achieved. On the other hand, biogas equivalent to 4.4 LPG cooking gas cylinder (12 kg) per year can be produced from the manure of a cow. This means an additional income of 400 TL year^{-1}. It is also envisaged that again manure of 1 cow will be reduced by 518 kg year^{-1} of greenhouse gas emissions as CO_2 equivalents by this method. When the reactor volume was increased from 1 m^3 to 100 m^3, the initial investment cost decreased from 1500 TL m^{-3} to 500 TL m^{-3}. The annual operating cost has changed between 150-300 TL m^{-3} (Approx. mean 217 TL m^{-3}). According to cost-benefit analysis, it is feasible to establish biogas plants for farms larger than 50 cattle. It has been concluded that the increase in the number of biogas plants in Turkey depends on the fact that biogas plants are produced in own domestic industry and are offered to the public at accessible costs. For this reason, it is proposed to increase incentives and supports for university-industry cooperation projects on anaerobic treatment and biogas production. It is also suggested that 75% of the installation and operation costs in these facilities should be supported by the government in order to increase environmental benefits.

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CONFERENCE PAPER

Detection of effective parameters in arsenic removal with capacitive deionization process and arsenic removal from wastewater

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ABSTRACT

Access to water is a problem the magnitude of which increases day by day. In addition to water scarcity, water contamination also plays an important part in the exacerbation of this problem. Underground and surface waters can be polluted as a result of human activities as well as natural sources. One of the most commonly found natural pollutants is arsenic. Risks and effects of arsenic on health make it necessary to be treated from water. Conventional methods of arsenic removal make it necessary for new studies to be conducted because of problems such economical and special equipment needs. The MCDI process stands out with its advantages such as being economic, flexibly and installation a package process. In this study, using the optimum conditions which are operating times, flow rate, current, voltage, number of cycles, previously determined for Voltea brand MCDI, the removal of arsenic from the wastewater produced by Emet Bor Operation Directorate Espey Open Quarry and Concentrator Facility, Hisarcik Open Quarry and Concentrator Facility and Boric Acid Production Facility during their activities has been studied. The removal efficiency of the MCDI process for arsenic was 94%.

Keywords: Arsenic, membrane capacitive deionization, groundwater

1. INTRODUCTION

The scarcity of drinking water sources in the world and pollution in the existing drinking waters threaten living beings, particularly human beings. The source of this pollution can either be human activities or through natural ways in the environment [1].

In addition to surface waters, groundwater is also widely used for drinking water. The sources of groundwater are generally surface waters, and they are formed by the accumulation of surface waters and rainfall in cracks rocks, and gaps. As well as being a source of drinking water, groundwater is of great importance for agriculture, livestock, mining and industry [2]. The waters can carry various impurities according to the soil and rock properties of the environment they are in. Common pollutants are arsenic, boron, iron, fluoride, lead and manganese [1].

Arsenic is a metalloid which is among common elements. It has an atomic number of 33, atomic mass of 74.92 amu and a density of 5.72 g cm^{-3}. 0.00015% of the earth's crust consists of this element, and its main species are arsenate, arsenite and arsenic sulfur [3]. Arsenic has been classified by the World Health Organization as a carcinogenic and toxic element found in water used for human consumption purposes. The maximum safe arsenic concentration that may be found in these waters as set by WHO is 10 μg L^{-1} [4]. Studies show that the concentration of arsenic in natural waters may reach 5000 μg L^{-1} [5]. However, arsenic concentrations in water may reach as high as 48,000 μg L^{-1} with anthropogenic arsenic pollution in various parts of the world [6].

Arsenic is known to cause problems associated with its accumulation in the body. Arsenic doses above 10 μg L^{-1} are considered toxic. There are clinical studies showing that concentrations above 100 μg L^{-1} may cause increased risk of bladder cancer, 150 μg L^{-1} and above an increase in the frequency of skin cancers, 200 μg L^{-1} and above chronic influence arsenicosis, and 300 - 400 μg L^{-1} may cause increased risk of lung

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and skin cancer and other skin diseases. At higher concentrations, various disorders such as vascular system damage (black foot) and diabetes can be seen [7].

Arsenic should be removed water before discharge to the environment to prevent its negative effects on health. Conventional methods such as coagulation and electrocoagulation, active alumina, ion exchange, zeolite adsorption and reverse osmosis have been previously used in this removal process [8–10]. The methods of arsenic removal are generally very successful. The development of new technologies are needed due to issues such as the formation of arsenic rich sludge, the need for expensive special equipment, and not being economical at low concentrations.

Capacitive deionization is a successful technology that has recently been used in desalination and purification processes. It was also reported to be effective in removal of heavy metals such as copper, iron and cadmium from aqueous solutions [11–14]. In addition to these ions, efforts have been made using CDI technology to remove ions and boric acid which cause hardness [15, 16]. There are also studies on removal of ions such as fluoride and nitrate chromium, including the removal of salt from underground waters, which are defined as hard water [17–19]. Studies have also been carried out on CDI for removal of arsenic which has low concentrations from water [20].

Arsenic species commonly found in natural waters are As (III) and As (V) predominantly, as negatively charged compounds of $H_2AsO_4^-$ ve $HAsO_4^{2-}$ [20].

Capacitive deionization process is the process of displacing ions in water by applying low voltages (1-2 V) to two parallel electrodes with water passing in between [21]. Compared with conventional systems, CDI results in energy efficiency, has a low energy potential, and directly uses electricity [21]. The simplicity of the CDI process, and its ability to be installed as a package can be seen as other advantages. The CDI process is made more efficient by using ion exchange membranes.

In this study, effective parameters were determined in arsenic removal by using membrane capacitive deionization process (MCDI). In addition, the efficiency of the MCDI process in arsenic removal was determined at different concentrations. Finally, arsenic removal process was performed on Eti Mining Operation wastewater using the MCDI process.of other languages in figures and tables is avoided. Papers should be checked by a native English speaker with expertise in the field prior to submission.

2. MATERIALS & METHODS

2.1. MCDI Process and Operation Conditions

The Voltea Brand MCDI system that was used in the study is schematically shown in Fig 1. The MCDI system consisted of 24 consecutive cells. Each cell contained a graphite current distributor (thickness δ = 250 μm), chemically identical porous carbon electrodes to work as cathode and anode (PACMM 203, Irvine, CA, USA, δe = 362 μm), anion- and cation-selective membranes to control ion flow (Neosepta AM-1 and Neosepta CM-1, Tokuyama Co., Japan, δ ≈ 130 μm) and textile separator (δ = 115 μm) that allowed water flow and separated the electrodes from each other. The resistance of the carbon electrodes was 1 (±0.2) Ω·cm^2, and the total electrode area was 1.18 m^2. The anion- and cation-selective membranes had resistance values of approximately 2 Ω·cm^2 [23].

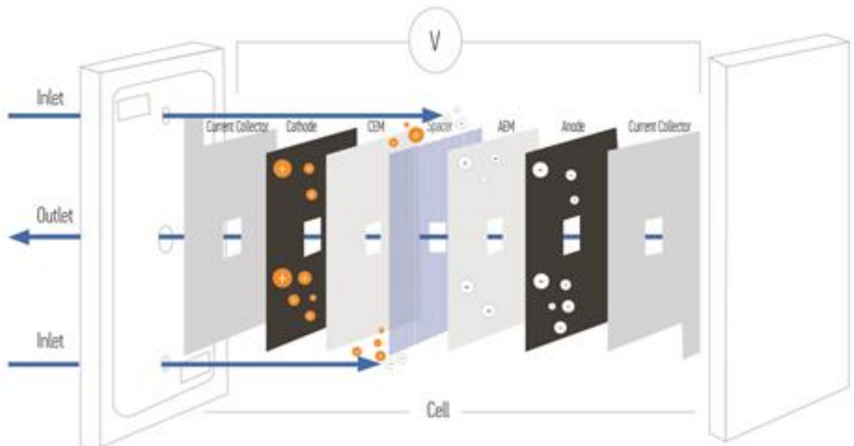

Fig 1. Schematic Representation of MCDI Process [22]

2.2. CDI Experiment

The CDI device could be operated automatically or manually at three stages. These stages were desorption (purification), preliminary (pre-purification) and desorption (wasting) stages. A single reactor was used for these stages, and the purified water and concentrated flow could be guided automatically from different channels. Additionally, in the CDI device, there was a preliminary treatment cell with a volume of 1L and a filter of 0.1μm porosity to prevent particulate matter from entering the reactor. There were conductivity probes in the inlet and purified water outlet channels of the reactor, and the conductivity values were automatically measured and transmitted to the computer via software. Values such as electrical potential difference (V), current (A) and pressure could be measured automatically.

The device could be operated manually, but it could also be operated automatically based on the principle of a model generating flow at a constant voltage, depending on values such as required efficiency, flow rate and input conductivity.

The potential and flow rate were kept constant in the MCDI system. The electrical potential difference was kept constant at 1.5V depending on the resistance to avoid hydrolysis conditions. Since the device reactor had a volume of 0.3L, it was kept at a flow rate of 0.3 L min^{-1} by adopting a fully mixed reactor. Energy consumption increased above this value, and it took a long time to fully discharge the reactor at the preliminary stage below this value. Depending on this, the volume of the concentrate flow increased. In the optimization experiments conducted with the MCDI system, the operating times were determined to be 1440 seconds for adsorption and 60 seconds for system preparation (complete removal of the concentrate present in the reactor and charging of the electrodes for adsorption/desorption). The duration of desorption varies depending on input conductivity [24].

2.3. Chemical Analysis

ICP MS was used for Arsenic and Boron measurements. Turbidimetric method was used for sulfate analysis, allowing analysis at a concentration of 1-40 mg L^{-1} SO_4^{2-}. The EDTA titrimetric method was used for the calcium analysis. Based on the results of calcium analysis, magnesium was found by calculation method based on EDTA titrimetric method. Ultraviolet spectrophotometric method used for NO_3^- analysis and argentometric method used for chloride analysis [Standart Methods].

2.4. Preparation of Synthetic Waters

Synthetic water ion contents used in laboratory studies were prepared with standard arsenic solution (H_2AsO_4 in HNO_3 0.5 mol L^{-1}), $NaNO_3$ and $MgSO_4.7H_2O$.

3. RESULTS & DISCUSSION

3.1. The Effect of Influent Concentration of Arsenic on Removal

Synthetic waters containing arsenic at different concentrations between 50 and 2000 μg L^{-1} were treated with the CDI system. As shown in Table 1, an increase in arsenic concentration led to an increase in removal efficiency. Ion intensity is a driving force in migration of ions to electrodes. The increase in removal efficiency was related to this.

Considering that the limit value determined by WHO is 10 μg L^{-1}, this limit value could only be reached at a 100 μg L^{-1} arsenic concentration with 93.69% treatment efficiency.

Table 1. Removal efficiency of different arsenic concentrations

Influent Concentration μg L^{-1}	Removal Efficiency %
50	91
100	93,69
200	93,87
300	94,91
400	95,62
500	96,23
750	97,59
1000	97,85
1500	98,34
2000	98,81

3.2. The Effect of Different Types and Amounts of Ionic Content on Arsenic Removal

The experiments on different ions continued with the value of 100 μg L^{-1} in which the limit value of arsenic concentration could be reached.

As: Cl^-, As: SO_4^{2-} and As: NO_3^- contents were prepared at 100 μg/L: 100 mg/L, and the effects of monovalent and divalent ions on removal efficiency were determined. As: Cl^-: NO_3^-: SO_4^{2-} was prepared at 100 μg L^{-1}: 100 mg L^{-1}: 100 mg L^{-1}: 100 mg L^{-1} to study the removal of As from synthetic groundwaters using CDI.

In the experiment conducted on As: Cl^- (100 μg L^{-1} : 100 mg L^{-1} and 100 μg L^{-1} : 200 mg L^{-1}) aqueous solution, arsenic removal efficiency was 98% and 98.7%, and Cl^- removal efficiency was 95% and 95.5%, respectively, as shown in the Fig 2. It was found that arsenic ions at a concentration of 100 μg L^{-1} were purified by CDI with a removal rate of 93.69%. However, as mentioned above, the ionic strength of the solution is the driving force when ions move to the electrodes. As the ionic strength of the solution increases, the removal efficiency of arsenic and Cl^- ions also increases.

In the experiments conducted with different As:NO_3^- concentrations (100 μg L^{-1} : 100 mg L^{-1} and 100 μg L^{-1} : 200 mg L^{-1}), Arsenic removal efficiency was found to be as 98.54% and 98.62%, and NO_3^- removal efficiency was found as 96.5% and 97.75%, respectively.

In the experiments conducted with different As: SO42- concentrations (100 μg L^{-1}: 100 mg L^{-1} and 100 μg L^{-1} : 200 mg L^{-1}), Arsenic removal efficiency was found as 99.06% and 99.36%, and SO_4^{2-} removal efficiency was found as 95% and 96.9%, respectively.

Comparison of the ion removal efficiencies is given in Fig 2. Increased ion concentrations have also increased recovery efficiencies.

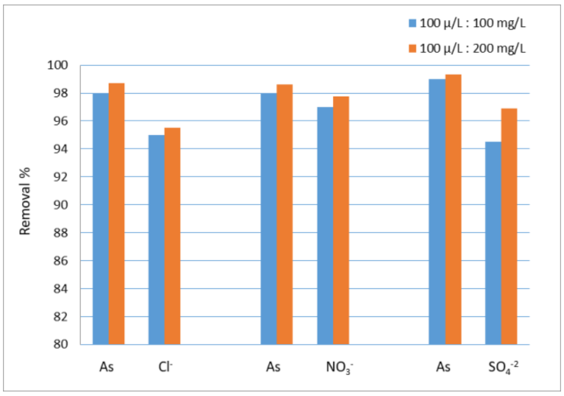

Fig 2. Ion removal efficiencies at different concentrations (100 µg L^{-1} : 100 mg L^{-1} and 100 µg L^{-1} : 200 mg L^{-1})

In the experiment conducted on As : Cl^- : NO_3^- : SO_4^{2-} solution (100 µg L^{-1} : 100 mg L^{-1} : 100 µg L^{-1} : 100 mg L^{-1}), removal efficiencies were 98.72%, 94.76%, 98%, and 95%, respectively and is shown in Fig 3.

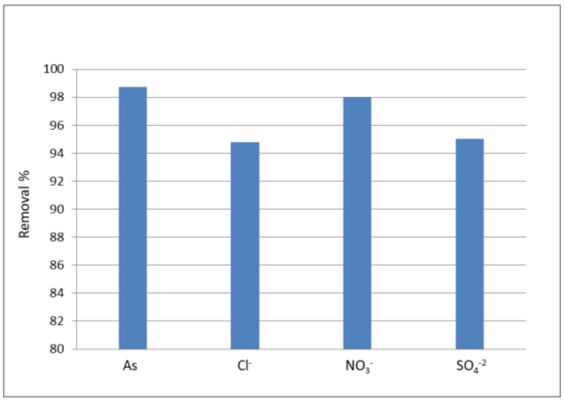

Fig 3. Ion removal efficiencies from synthetic groundwater (As : Cl^- : NO_3^- : SO_4^{-2}, 100 µg L^{-1}: 100 mg L^{-1}: 100 µg L^{-1}: 100 mg L^{-1})

It is known that there are many different effects in the adsorption of ions from solution to the electrode surface. Most important ones are pore size of the electrodes and ions hydrated radii. Also the high ionic valence is important for the effective removal of ions. The sequence of the hydrated radii of the ions was SO_4^{2-} (3.79 Å)> NO_3^- (3.35 Å)> Cl^- (3.31 Å), respectively. Former studies with CDI have presented diversing consequences related to the preferential selection of ions. Studies have shown that the pore size of the electrodes, including micropores (<2 nm) and mesopores (2-50 nm), and the distributions of these sizes cause the ions to show very variable tendencies in their preferential migration to the electrodes. As a consequance, the reason for more efficient removal of monovalent ions than divalent ions is the outcome of the fact that divalent ions (6-7A^0 in diameter) cannot be adsorbed into the pores in the electrode surface area because of the reduction of the small-sized pores by monovalent ions (4A^0 in diameter) [22].

Considering the studies done with different concentration, arsenic removal efficiencies are close to each other. Cl^- and SO_4^{2-} removal efficiencies are also close to each other when evaluated together with experimental errors. Accordingly, a sequence of As ≡ NO_3^-> SO_4^{2-} ≡ Cl^- can be mentioned.

3.3. Treatment of Mine Wastewaters having Arsenic with CDI

In this study, wastewaters produced as a result of the activities of Espey Open Pit Mining and Concentrator Facility, Hisarcık Open Pit Mining and Concentrator Facility and Boric Acid Production Facility of Emet Boron Processing Directorate located in Kütahya province of Turkey were treated. The characteristics of the wastewater are presented in Table 2. The CDI process is generally quite successful up to 5000 µS cm^{-1}. Due to high water conductivity, the experiments were conducted on 70% diluted samples.

Based on the results of the study, it was observed that the arsenic could be removed with a maximum efficiency of 94%. As shown in Table 2, removal efficiencies for SO_4^{2-}, Cl^-, and B anions were 99%, 90% and 81%, respectively; and removal efficiencies for Mg^{2+}, Ca^{2+}, and Na^+ cations were 99%, 98% and 88%, respectively.

As a result of these studies, it can be seen that the standard for arsenic has been met as <10 µg L^{-1}. It has been demonstrated that MCDI process can be successfully used in arsenic removal from groundwater, surface water, and wastewater.

Table 2. Wastewater characteristic of boron mining facility

Component	Unit	Feed groundwater	Sample diluted %70	Purified groundwater mg L^{-1}	Removal Efficiency %
pH	-	4,5	6,8	7,2	-
Cl^-	ppm	33,5	10	1	90
SO_4^{2-}	ppm	7352	2206	20	99
As	ppm	7	2.1	0.0087	99
B	ppm	4976	1493	54.84	81
Ca^{2+}	ppm	545	164	2.5	98
Mg^{2+}	ppm	952	286	3	99
Na^+	ppm	150	45	5	88
İletkenlik	µS	6040	2000	62	97

As shown in Table 3, in the first and second cycles, the potentials are 1.2 and 1.3 V, respectively, and the current values are 25 A and 15 A, respectively. The conductivity retention is finally 97.6%.

All deionization processes can be used for arsenic removal. In a study conducted by electrodialysis, wastewater containing arsenic was treated in the range of 2.1 - 15 mg L^{-1} arsenic and potential was used in the range of 10 - 20 V and current in the range of 4.5 - 11.3 A was used. At the end of 400 minutes, the arsenic concentration could be lowered to less than 10 µg L^{-1} [25]. In another study, ferric chloride and ferric sulfate coagulant materials were used to treat water containing 30 µg L^{-1} arsenic and purified 99% [26]. In a study with reverse osmosis, water containing between 100 and 382 µg L^{-1} arsenic was tried to be treated and 93% - 99% removal efficiencies were obtained [27].

Table 3. Energy Expenditures and Recoveries within treatment

Process Information	Unit	Cycle 1	Cycle 2
Initial Conductivity	µS cm^{-1}	6050	2844
Average Removal Rate (for conductivity)	%	53	95
Average Current Density	A	25.3	15
Average Voltage	V	1.2	1.3
Water Recovery	%	65	68

As a result, comparing MCDI with other deionization methods, it can be seen that MCDI is quite successful in arsenic removal. MCDI is an energy efficient process when compared to electrochemical methods.

4. CONCLUSIONS

Underground and surface waters are exposed to arsenic pollution due to both human and natural causes. Arsenic is a pollutant that must be treated since it has a serious hazard endangering living organisms. MCDI process is a new technology that is very successful in ion removal. In this study, the mechanism of arsenic removal was tried to be determined by using optimum conditions (operation time, flow, current, voltage, number of cycles) previously determined for Voltea brand MCDI system. Arsenic was lowered below the 10 µg L^{-1} limit in studies conducted on synthetic solutions. Moreover, arsenic was tried to be removed from wastewaters produced as a result of the activities of Espey Open Pit Mining and Concentrator Facility, Hisarcık Open Pit Mining and Concentrator Facility and Boric Acid Production Facility of Emet Boron Processing Directorate located in Kütahya, province of Turkey. Arsenic removal efficiency in these wasterwaters containing 2100 µg L^{-1} arsenic was 99.5%. When the effect of other ions and electron selectivity in the removal of arsenic ions from wastewaters by MCDI process was examined, it was found that the order for anions was As ≡ SO_4^{2-} > Cl^- > B, and the order for cations was Mg^{2+} ≡ Ca^{2+} > Na^+.

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CONFERENCE PAPER

Application of Analytic Network Process (ANP) and PROMETHEE for different treatment/disposal technologies of persistent organic pollutants (POPs)

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ABSTRACT

Persistent organic pollutants (POPs) are a group of hazardous chemicals that have persistent, bio accumulative and toxic properties regulated under Stockholm Convention (SC). This study was to a large extent focusing on selecting the appropriate treatment/disposal technologies for environmentally sound disposal of POPs in compliant with SC obligations. For this purpose, five different technologies were evaluated by Analytic Network Process (ANP) and PROMETHEE methods which are the most well-known Multi Criteria Decision Making (MCDM) methods. These technologies are incineration, base-catalyzed decomposition (BCD), gas phase chemical reduction (GPCR), pyrolysis/gasification and plasma arc. Eleven criteria by means of benefit, cost and risk were used for evaluation. Incineration was found as the preferred alternative for both methods (34 % for ANP and +0.41 for PROMETHEE). The second option for ANP and PROMETHEE was plasma arc (24%) and pyrolysis/gasification/ (+0.23), respectively. Although the results were slightly different for two options, this difference is due to the mathematical differences between the methods.

Keywords: ANP, MCDM, POPs disposal, PROMETHEE, treatment, waste

1. INTRODUCTION

Persistent Organic Pollutants (POPs) are globally concerned group of chemicals due to their resistant in nature, highly toxic properties including teratogenic, carcinogenic, endocrine disrupting effects and transboundary movement due to their semi-volatile characteristics [1]. POPs were used in several industrial processes and products. Even if the use of POPs is prohibited, it will continue to be in products and waste streams for many years. Furthermore, some treatment/disposal technologies can lead to the unintentional formation and release of POPs [2].

Several multilateral environmental agreements provide frameworks to prevent and minimize releases of toxic chemicals and hazardous wastes. The Basel, Stockholm and Rotterdam Conventions are a series of building blocks that dovetail to create a comprehensive life cycle approach to the management of hazardous chemicals and wastes. Together, these conventions guide decision makers in their actions to minimize and manage the risks to the environment from a range of chemicals, products and wastes [3].

Provisions of the Stockholm Convention complement with the related articles for the management of hazardous wastes under the Basel Convention to form a comprehensive regime for managing POP wastes. These obligations coming from the two conventions are to be applied to POP wastes in making decisions about their Environmentally Sound Management (ESM) [4, 5]. ESM is a broad policy concept that is understood and implemented in various ways by different countries, stakeholders and organizations.

Within the abovementioned ESM framework, the following POPs destruction technologies, as provided in the Basel Convention, has been permitted for the destruction and irreversible transformation of the POP wastes when applied in a way that ensures the remaining wastes and releases do not present the characteristics of POPs:

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(a) Alkali metal reduction

(b) Advanced solid waste incineration (ASWI)

(c) Base catalyzed decomposition (BCD)

(d) Catalytic hydrodechlorination (CHD)

(e) Cement kiln co-incineration

(f) Gas phase chemical reduction (GPCR)

(g) Hazardous waste incineration

(h) Plasma arc

(i) Plasma melting decomposition method (PMD)

(j) Supercritical water oxidation (SCWO) and subcritical water oxidation

(k) Thermal and metallurgical production of metals

Among these technologies, one technology can be in front of the other based on technical specifications or commercial availability in a country. In addition, different real-life parameters such as investment cost, pre-treatment option, distance, etc. can also affect the selection of proper disposal method in reality.

Multi-criteria decision making (MCDM) methods which has been used in this study are very commonly used in decision making studies. MCDM tools may be applied in many decision-making in problems for several environment related studies including waste management for either site selection or strategy development [6-10]. In the area of the study, MCDM tools were generally used for selection of the most suitable locations for establishment of waste management centers for municipal solid waste or other type of wastes. But studies used for either selection of site of determination of disposal/treatment strategy focuses mainly on municipal solid waste, recyclable waste, waste electrical and electronic equipment and medical waste. However, in some studies they were used for selection of appropriate technologies for medical waste treatment and wastewater treatment [11-13]. There are several tools that are used in MCDM studies such as target programming, Analytical Hierarchy Process (AHP), Analytical Network Process (ANP), Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE), TOPSIS and ELECTRE [14, 15]. In this study, ANP and PROMETHEE were selected as appropriate MCDM tools for assessment and comparison of POPs destruction technologies.

The ANP offers an approach to enter judgments and measurements to develop ratio scale priorities for the distribution of impact among the factors and groups of factors in the decision. Whereas the basic ANP structure consists of only one network, the most complex one can analyze the benefit, opportunity, cost and risk (BOCR) that each alternative can cause together. In ANP, to define the significance of the criteria and alternatives among each other, a pairwise comparison is conducted. In addition, comparison of alternatives is done for each criterion. To make a prioritization among the many objectives and many criteria, the judgments that are usually made in qualitative terms are expressed numerically. To do this, rather than simply assigning a score out of a person's memory that appears reasonable, one must make reciprocal pairwise comparisons in a carefully designed scientific way. However, in case of a non-numeric criterion, it is used to assign a score that was developed by Saaty ranging from 1 to 9 [15].

PROMETHEE method was firstly developed by Brans in 1982 and it was extended in 1985 by Brans and Vincke [16]. In this method, data entries can be used directly without making any pairwise comparison. In order to implement PROMETHEE, two types of data are required that are relative significance of the criteria (weights) and values of alternatives according to criteria with respect to decision makers choice (function) [17]. The method accepts the decision maker's weighting as correct. The preference function in PROMETHEE, translates the difference between the evaluations of two alternatives into a preference degree ranging from 0 to 1 for each criterion [18]. There are 6 types of preference function that are usual, U-type, V-type, level, linear and Gaussian. For each criterion, a sensitivity threshold (q) if the function type is U-type; preference threshold (p) if the function is V-type or Gaussian; and both sensitivity and preference thresholds should be defined if the function is linear or level. There is no need for a threshold in usual preference function. PROMETHEE method consists of 5 steps. The procedure starts with determination of deviations from pair comparisons. Then, global preference index is calculated for each criterion by using the appropriate preference function (step 2 and 3). In step 4, positive and negative dominant flows are calculated for each alternative and partial ranking is conducted. In the final step, the procedure is completed by calculation of net dominant flow for each alternative and conducting a complete ranking [17, 18].

2. MATERIALS & METHODS

In this study two different MCDM methods were used: ANP and PROMETHEE. In both methods, the same alternatives and criteria were used for resolving the problem. The flowchart of the study was illustrated in Fig 1.

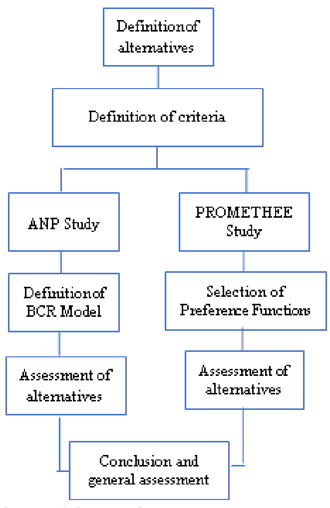

Fig 1. Flow chart of the study

2.1. Definition of Alternatives

The alternative technologies were selected according to the report prepared by Scientific and Technical Advisory Panel (STAP) of Global Environmental Facility (GEF) [16]. In this context, Incineration (A1), Base-Catalyzed Decomposition (BCD) (A2), Gas Phase Chemical Reduction (GPCR) (A3), Pyrolysis/Gasification (A4) and Plasma Arc (A5) were used as alternative technologies. These technologies were defined as commercial destruction/irreversible destruction technologies for POPs by GEF STAP.

2.2. Incineration (A1)

Hazardous waste incineration mainly uses flame combustion to treat organic contaminants, mostly in rotary kilns. The process typically involves heating to the temperature greater than 850°C or 1100°C (if the waste contains more than 1% of halogenated organic substances i.e. as chlorine) for a residence time greater than 2s under conditions that ensure appropriate mixing. Dedicated hazardous waste incinerators are available in a number of configurations, including rotary kiln incinerators and static ovens (for liquids with low contamination). High-efficiency boilers and lightweight aggregate kilns are also used for the co-incineration of hazardous wastes [2, 20].

2.3. Base-Catalyzed Decomposition (BCD) (A2)

The BCD process involves treatment of wastes in the presence of a reagent mixture consisting of a hydrogen-donor oil, an alkali metal hydroxide and a proprietary catalyst. When the mixture is heated to above 300 °C, it makes highly reactive atomic hydrogen that reacts with the waste to remove constituents that confer toxicity to the compounds [2, 21].

2.4. Gas Phase Chemical Reduction (GPCR) (A3)

The GPCR process involves the thermochemical reduction of organic compounds. At the temperatures greater than 850 °C and at low pressures, hydrogen reacts with chlorinated organic compounds to yield primarily methane, hydrogen chloride (if the waste is chlorinated), and minor amounts of low molecular weight hydrocarbons (benzene and ethylene). The hydrochloric acid is neutralized through the addition of caustic soda during the initial cooling of the process gas or can be taken off in acid form for reuse. The GPCR technology can be broken down into three basic unit operations: a front-end system (where the contaminants are transformed into a suitable form for destruction in the reactor), a reactor (which reduces the contaminants using hydrogen and steam), and a gas scrubbing and compression system [2, 21].

2.5. Pyrolysis/Gasification (A4)

Pyrolysis and gasification attempt to reduce the volume of waste by converting it into synthetic gas or oils, followed by combustion [19]. Gasification is a pre-treatment/treatment technology for the recovery of hydrocarbon-containing waste which is operated at high temperatures and at high pressure using steam and pure oxygen in a reduced atmosphere. All hydrocarbon molecules in the waste are irreversibly decomposed to small gaseous molecules such as hydrogen (H_2), carbon monoxide (CO), methane (CH_4) and carbon dioxide (CO_2). Short-chain hydrocarbons such as ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}) and other compounds are produced in small amounts (< 1 vol. %). Persistent organic pollutants including PCBs contained in the waste are effectively destroyed. The resulting raw gas is subsequently converted in a multistage process to pure synthesis gas for the production of highest-grade methanol [2, 23]. Pyrolysis is a similar approach which applies heat with no added oxygen in order to generate oils and/or syngas (as well as solid waste outputs) and requires more homogenous waste streams [19]. Different than Plasma Arc technologies, Pyrolysis/Gasification involve a plasma arc but destruction results from the heat generated by the arc, generally at lower temperature [19].

2.6. Plasma Arc (A5)

The waste in the form of liquid or gas, is injected directly into the plasma and is rapidly (<1 ms) heat up to about 3100°C and pyrolyzed for about 20 ms in the water-cooled reaction chamber (flight tube). The high temperature causes compounds to dissociate into their elemental ions and atoms. Recombination occurs in a cooler area of the reaction chamber, followed by a quench, resulting in the formation of simple molecules. The plasma arc system requires a mono-nitrogen oxides (NO_x) abatement device, as important amounts of NO_x are produced by the high temperature flame [2, 21].

2.7. Definition of Criteria

In this study, the following criteria listed in Table 1 was used for both ANP and PROMETHEE methods. In addition, in "benefit, opportunity, cost and risk" analysis of ANP method, benefit and opportunity clusters were combined and "benefit, cost and risk" analysis was conducted.

2.8. ANP Study

In order to assess the most suitable POPs treatment/disposal technology via ANP method, Super Decision software was used. For this purpose, a benefit, cost and risk analysis were conducted according to performance values listed in Table 2. For criteria between g4-g8, direct data was entered but for the rest scoring method through pairwise comparison was applied. It was pointed out that the inconsistency ratios were less than 10% due to the nature of the method [21].

The significance of the weighting of the chosen criteria was formulated in the program as additive (reciprocal):

Formula:

$$bB + oO + c\,(1/C) + r\,(1/R) \quad \text{with } r = 1/2;\ c = 1/3;\ b = 1/6;\ \text{and } o = 0 \qquad (1)$$

where B is Benefit, O is Opportunity, C is Cost and R is Risk.

In this context, first each cluster is rated separately. Then, these ratings are combined using the cluster weighting and the formulas including that to multiply the benefit ratios, reciprocals of cost and risk ratios. Finally, these raw results are normalized, and the values can be used as percentages for the evaluation of the alternatives [25].

Table 1. Criteria used in ANP and PROMETHEE methods

No	Name	Unit/Score	Remarks
Benefit Cluster (for ANP)			
g1	Disposal time	Day, decreasing	Number of days for disposal of same amount of POPs waste
g2	Chemical usage	Score (1-9), decreasing	Amount of chemicals added to process for disposal of same amount of POPs waste
g3	Easy application	Score (1-9), increasing	Complexity and difficultness of the application
g4	Destruction Efficiency (DE)	%, decreasing	Destruction performance of the method
g5	Destruction and Removal Efficiency (DRE)	%, decreasing	Destruction and removal performance of the method
Cost Cluster (for ANP)			
g6	Operation cost	$/ton, decreasing	Amount of operation cost including energy, water, labor cost for disposal of same amount of POPs waste
g7	Preparation cost	$/ton, decreasing	Amount of preparation cost for disposal of same amount of POPs waste
g8	Capital cost	$/ton, decreasing	Amount of investment cost including infrastructure and equipment for disposal of same amount of POPs waste
Risk Cluster (for ANP)			
g9	Effective distance	m, decreasing	Distance of waste to the facility
g10	Climate conditions	Score (1-9), increasing	Influence of climate on the method
g11	Waste/Emission generation	Score (1-9), decreasing	Amount of waste/emission generated during the disposal of the same amount of waste

Table 2. Performance values of criteria

No	A1	A2	A3	A4	A5
g1	2	8	7	6	6
g2	3	7	8	3	2
g3	1	4	8	6	8
g4	99.999	99.9999	99.9999	99.974	99.9999
g5	99.9999	99.9999	99.9999	99.9999	n.a.
g6	1000	1500	1200	900	2000
g7	100	400	300	250	300
g8	10	2-3	7-9	12	12
g9	2	5	6	3	8
g10	1	9	9	1	1
g11	3	6	5	3	2

2.9. PROMETHEE Study

In application of PROMETHEE method, academic version of D-Sight software was used. Assessment was conducted with the data given in Table 2. Usual preference function was used in the criteria that has numeric values, the most appropriate and common Gauss function, and that has scoring values (1-9). Criteria properties and weights were provided in Table 3. Sum of the weighting values is equal to 1 and the most dominant cluster of criteria was risk cluster.

Table 3. Criteria properties and weights for PROMETHEE

Criteria	Minimum/ Maximum	Function Type	Absolute/ Relative	Weights	Unit
g1	Minimum	Usual	Relative	1.6	1-9
g2	Minimum	Usual	Relative	0.5	1-9
g3	Maximum	Usual	Relative	1.2	1-9
g4	Maximum	Gauss	Absolute	6.8	%
g5	Maximum	Gauss	Absolute	6.5	%
g6	Minimum	Gauss	Absolute	20.4	\$ ton^{-1}
g7	Minimum	Gauss	Absolute	9.0	\$ ton^{-1}
g8	Minimum	Gauss	Absolute	3.9	\$ ton^{-1}
g9	Minimum	Usual	Relative	14.3	1-9
g10	Minimum	Usual	Relative	3.1	1-9
g11	Minimum	Usual	Relative	32.6	1-9

3. RESULTS & DISCUSSION

The alternatives for choosing the most appropriate technology for environmentally sound treatment/disposal of POPs wastes were evaluated with ANP and PROMETHEE methods. The results of ANP method in terms of benefit, cost and risk were given in Fig 2 in addition to aggregated results of clusters. According to the figure, the most appropriate alternative for benefits is plasma arc whereas the incineration is the most appropriate one for the cost and risk. On the other hand, overall results which aggregated based on the weight of clusters show that incineration should be the most preferable technology for destruction of POPs.

The preference ranking of alternatives obtained by PROMETHEE method is presented in Fig3. In this figure, highest positive score shows the most appropriate alternative. In this context, incineration (a1) is the most preferable method and followed by pyrolysis/gasification. Despite its positive value, plasma arc (a5) has relatively lower score compared to incineration and pyrolysis/gasification. On the other hand, base-catalyzed decomposition (BCD) (a2) and gas phase chemical reduction (a3) has negative scores that shows their non-compliance.

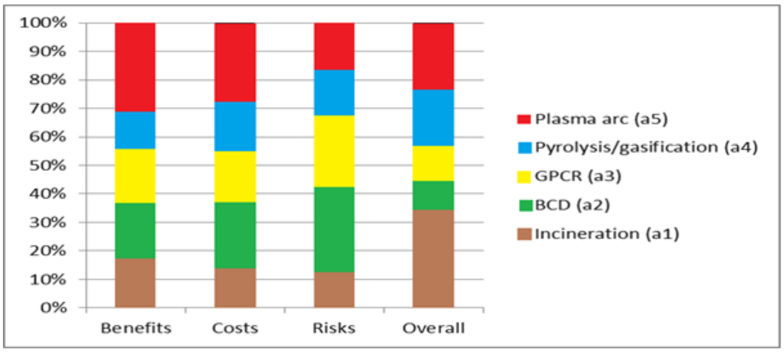

Fig 2. ANP results in terms of benefit, cost, risk and overall

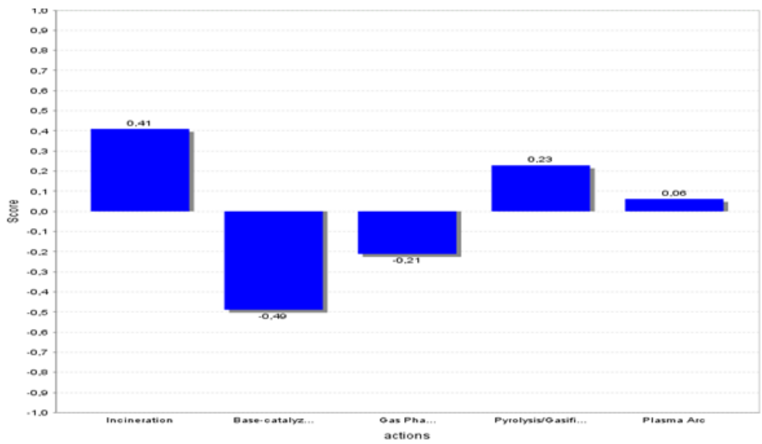

Fig 3. Ranking of alternatives with PROMETHEE

Results obtained in both MCDM methods were compared in Table 4. In both methods, incineration is the most appropriate technology for environmentally sound treatment/disposal of POPs wastes. BCD and GPCR take place in the same order in both methods. On the other hand, the plasma arc is the second in ANP- the third in PROMETHEE and vice versa for pyrolysis/gasification. While considering the most criteria for these two alternatives are relatively close to each other this kind of a shift might be reasonable expected.

Table 4. Comparison results of POPs treatment/disposal technologies with ANP and PROMETHEE

Alternatives	Ranking	
	ANP	PROMETHEE
Incineration (a1)	1	1
Base-catalyzed decomposition (BCD) (a2)	5	5
Gas Phase Chemical Reduction (GPCR) (a3)	4	4
Pyrolysis/Gasification (a4)	3	2
Plasma Arc (a5)	2	3

4. CONCLUSIONS

Several commercial/near commercial technologies are available for environmentally sound disposal/destruction of POPs. However, due to availability and pollution specific circumstances different technologies can be accepted as more appropriate than others for all kinds of POPs treatment/disposal activities in a country. Technical (Destruction Efficiency, Destruction and Removal Efficiency, waste release/emission, chemical usage, etc.) and economical (operation costs, preparation costs, capital costs, etc.) criteria should be considered to choose a technology. At this point, MCDM methods help to decision makers for strategic planning of similar problems. However, there is not a wide usage of MCDM tools for determination of appropriate disposal/treatment technologies for hazardous wastes such as POPs. In the present study, ANP and PROMETHEE were used to decide which treatment/disposal technology best fits for POPs. It is thought that this study may serve as an example for different countries. According to the evaluations using both techniques, incineration was found to be the most appropriate option for treatment of POPs in Turkey. Since there is about 10% difference from the next alternatives in the ranking, it can be said that the result is robust. The main factors influencing this result were low cost and risk. Policies for dissemination of POPs disposal/treatment technologies among the country should consider these parameters and the results.

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CONFERENCE PAPER

Some properties of pellets made of spruce and beech torrefied sawdust

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ABSTRACT

The paper aims to determine the physical properties (density) and calorific ones (calorific value and ash content) of pellets made of spruce and beech sawdust, thermally treated at temperatures of 170, 190 and 210 °C, for 1, 2 and 3 hours. After the thermal treatment of the sawdust, its mass loss was obtained, and compressed pellets were obtained under laboratory conditions. The results obtained from sawdust treatment indicated a weak increase in calorific value, depending on the temperature and the thermal treatment times. The final conclusion of the paper is that the thermal treatment improves the caloric properties of sawdust pellets, the beech sawdust having a higher capacity for torrefaction and compaction related to spruce sawdust.

Keywords: Ash content, calorific value, thermal treatment, wooden pellets

1. INTRODUCTION

Wooden pellets are obtained from sawdust with a certain granulometry, compressed to a density usually over 1.0 g cm^{-3} [1]. The sawdust is not cut especially for this use and is taken from other factories as timber, such as wood waste. From this point of view sawdust can be considered as a sort of wooden biomass. At worldwide level, biomass covered about 70% of the energy necessary in the year of 1870. Then, biomass lost high level in front of methane gas, coal and photovoltaic fuels. Currently, biomass continues to be the main fuel from which the energy in the countries with ongoing development is produced [2]. During the last years, there have been noticed favorable changes in the energy field, by obtaining energy from alternative non-conventional sources. The European Union wishes that the production from alternate sources reaches 20% in the year of 2020, of all the produced energy [3, 4]. Reaching this threshold implies a series of other factors favorable to development, and there are mentioned the emissions of carbon dioxide, which, in comparison with the year of 1990, until 2020 must decrease with 20% [5] according to the proposals of the European Union, by using and exploiting alternate sources of energy [6]. Using of energy crops such as Salix viminalis [7] conducted to use of whole biomass from harvesting and transforming it into pellets and briquettes with superior characteristics.

Biomass is environmental friendly because the dioxide of carbon is absorbed by plants during growth and will forms a closed circuit [8], because the carbon dioxide quantity which was absorbed by plants during growth will be equal with the same quantity eliminated during the complete combustion process (Fig 1). From this point of view the use of wooden biomass in combustion has a neutral effect and all combustibles from biomass are environmental neutrally.

The wooden pellets are state-of-the-art lignocellulosic energy products, obtained from small size lignocellulosic biomass (dust, sawdust and fine chips) and compacted under the form of cylinders with usual diameter of 6-10 mm [9, 10]. The pellets are engineering fuel products, which incorporate a high technology. Their dimensional uniformity, the density

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and other mechanical features make possible the automated process of the combustion and autonomy of the thermal plant of 12-24 hours [11].

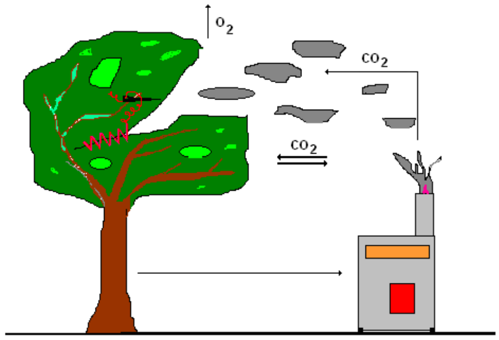


Fig 1. Closed circle of CO_2 of biomass combustion inside the naturally environment

The advantages of pellets using are as follows: they offer a reduction of fossil fuels dependency; they are renewable fuels, obtained from the small size lignocellulosic biomass; they are not degradable during storage, due to the low level of moisture content and the fact that they are delivered and kept as wrapped at about 10 % moisture content; they have a good energetic value, equivalent of the raw material from which is made; they have a very high energetic density, much higher than the one of massive wood and briquettes. The disadvantages of pellets are weakly, especially when they are compared with the lignocellulosic briquettes [12, 13]. But, when they are compared to fossil fuels or fire wood, there are a couple of disadvantages, among which the following are evidential [14]: difficult processing of raw material in order to obtain the finite product, in comparison with the fossil fuels where only their extraction is needed; additional investment towards the use of fire wood [15]; collection and processing of the ash resulted after combustion [16].

Even if the pellet machines are different [17], the features of the pellets are almost identical. Pellet properties are constantly because they are subject to a multi-state international standard. The limitative technical features of the pellets expressed by the European Standard EN 14961-1 [18, 19] are: diameter of 4-10 mm; length smaller than 50 mm; bulk density of 650 kg m^{-3}; effective density higher than 1200 kg m^{-3}; moisture content lower than 8%; ash content lower than 1.5%; calorific value of 16.9-19.5 MJ kg^{-1}. These characteristics are almost the same all over the world.

Torrefaction of wooden material is a dry thermal process, which started from the premise of reducing the higroscopicity and biodegradability. The beginning of the torrefaction process was applied firstly to tobacco, then to the timber, followed by the plywood, the chipboard, the pile and of course to the briquettes and pellets. The issue of increasing calorific power of treated pellets was less researched [20], [21]. Also, the increase in ash content during torrefaction was less researched, the increase being due to carbon enrichment by torrefaction treatment [22, 23]. One last problem less researched is the use of torrefied sawdust to create stable and less flamboyant pellets. Being a relatively new process, this thermal treatment has many unknowns and each research in this field will try to find those areas still untested or not enough researched.

Main objective of the paper is to research the sawdust torrefaction treatment with weak temperature of 170-210 °C inside of low-oxygenated oven, with direct influence upon of some pellet characteristics. This influence will be directional toward the density, calorific value and ash content of spruce and beech sawdust and pellets.

2. MATERIALS AND METHOD

There were used two types of sawdust species, respectively spruce (Picea abies L) and beech (Fagus sylvatica L), both of them taken from a circular saw of practice laboratory when these species were cut. In order to obtain a good thermal treatment and to create a dimensional uniformity of the sawdust particles there were used two sieves with the dimensions of 3x3 and 1x1 mm, eliminating the extreme particles from the sorting operation with these sieves. Then the sawdust of both species was conditioned for 48 hours in order to obtain a moisture content of about 10%. From this sawdust there were produced the blank pellets, which will be still used for comparison with the ones made of torrefied sawdust.

For the thermal treatment of sawdust a Memmert (German producer) oven was used which has had the possibility to raise the temperature toward 220 °C. The sawdust was placed on metallic crucibles, previously cleaned and weighed. First, the sawdust was dried to a constant mass at a temperature of 105 °C, after which it was weighed and noted down all the crucibles mass. Thereafter, the crucibles were introduced into a controlled cooking oven at a temperature of 650 °C, at which the air inlet was closed, and the torrefaction occurred in a poorly oxygenated environment. After 1 hour, the first batch of crucibles was removed and weighed to a precision of 0.001 g. They were placed in the conditioning chamber in order to bring them to a moisture content of 10%. After the torrefied sawdust was conditioned, there were made pellets with a diameter of about 12 mm and a mass of 0.5-0.9 g. After two hours of treatment, the second batch of crucibles was extracted from the oven and after 3 hours the last batch of crucibles was extracted. From each batch some pellets are made, but it also preserved some materials that will be used to determine the ash content. Then, other quantity of sawdust was torrefied at 190 °C and 210 °C, following the same procedure as it was used at 170 °C. In this way there were obtained pellets from torrefied sawdust at temperatures of 170, 190, and 210 °C, and at 1, 2, and 3 hours of treatment [24].

The pelletisation was performed with a hand-operated press device, an existing device that equipped the calorimeter used to determine the calorific power. The obtained pellets were introduced into sealed polyethylene folium, specifying the type of wood species (spruce, beech, control/ torrefied) and the torrefaction degrees (170/1; 170/2; 170/3 and so on, where 170 is temperature in °C and 1, 2, and 3 are time of torrefaction expressed in hours).

For determination of the effective density of the pellets, there were chosen randomly 10 pieces of pellets, each ends have been polished by grinding in order to get a surface perfectly perpendicular on their length and lastly a right circular cylinder. Therefore, keeping into account the volume of circular cylinder, the below relation has been used:

$$\rho_{ef} = \frac{4m}{\pi d^2 l} 10^3 \ \ [\text{g cm}^{-3}] \quad (1)$$

Where: m is pellet mass, in g; d- pellet diameter, in mm; l-pellet length, in mm.

The installation used for determining the caloric power of the pellets was the explosive burning calorimeter type XRY-1C, produced by Shanghai Changji Geological Instrument Co. from China. This calorimeter used o bomb (Fig 2a) with high oxygen pressure of 30 bar and had an own soft for work and express all results (Fig 2b).

(a) (b)

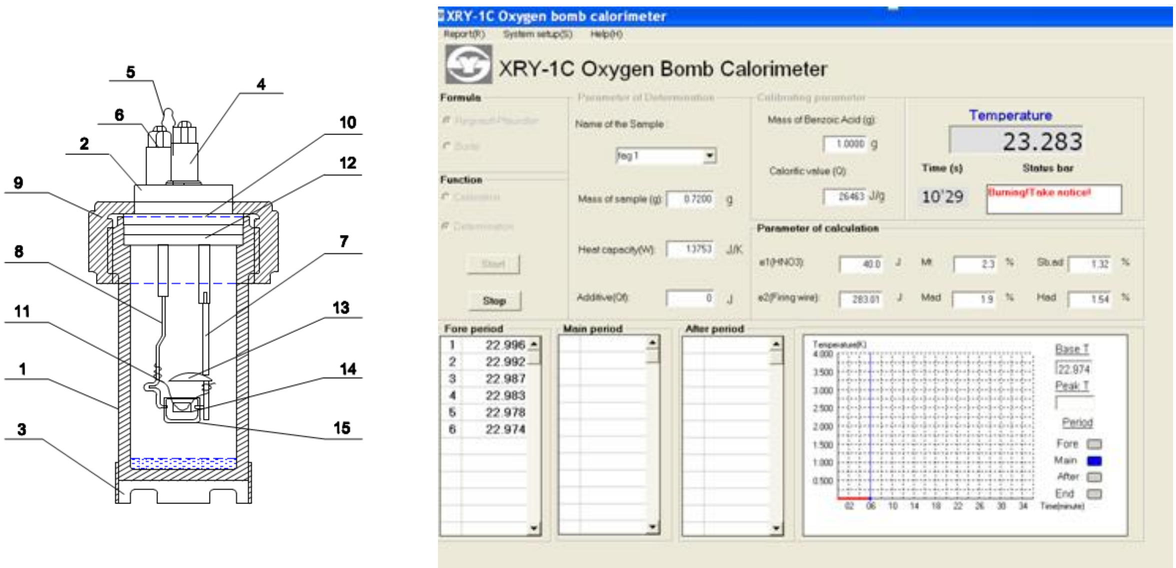


Fig 2. Determination of calorific value: (a) Section view through calorimetric bomb; 1-body, 2-lid, 3-socle, 4-couple of current 1, 5-admision of oxygen, 6-couple of current 2, 7-metal fir, 8-metal fir 2, 9- gasket 1, 10-gasket 2, 11-pellet, 12-protective sheet 1, 13-protective sheet 2, 14-nikel wire, 15-crucible; (b) interface of computer soft

Before to the test, the calibration of the calorimetric bomb was made with benzoic acid, with a known value of caloric power (26 463 kJ kg^{-1}).The method to determine the caloric power of the wooden material referred mainly to the preparation of the raw material and the installation, then to the proper determination and finally to the obtaining of the results [25, 26].

The test has contained of three different stages:

-The initial stage ("fore") had as purpose the determination of temperature variations of water in the calorimetric recipient, due to the heat exchange with the exterior before burning;

-The main period ("main") began by burning the sample and has as consequence the increase of water temperature in the calorimetric recipient, due to the burning of wooden particles and heat delivery to exterior;

-The final period ("after") had as purpose the determination of the average water temperature in the calorimetric recipient, due to the heat exchange with the exterior after burning.

The caloric power for both non-torrefied and torrefied pellets had been determined using at least 10 samples (in the form of compacted pellets) of 0.6-0.8 g. The calculation relation for the calorific power determination was:

$$CV = \frac{C(t_f t_i}{m} - q_s \ \ [\text{kJ kg}^{-1}] \quad (2)$$

where: CV is the caloric power (kJ kg^{-1}); C-calorimetric constant, determined by calibrating the device with benzoic acid (kJ(°C)$^{-1}$); t_f- final temperature, read by the thermocouple of the calorimeter, °C; t_i- initial temperature, read by the thermocouple of the calorimeter, °C; qs- heat quantity issued by the nickel and cotton wires.

The increase of calorific power (ICV) (but also for other parameters determined in the paper) from one thermal regime to another was determined with the following relation:

$$I_{CV} = \frac{FV_{CV} - IV_{CV}}{IV_{CV}} \cdot 100 \ [\%] \quad (3)$$

where: FV_{CV} is final value of calorific value; IV_{CV}- initial value of calorific value.

Determination of the ash content used non-torrefied sorted sawdust of spruce and beech, and also torrefied sawdust with different degrees of torrefaction. Dried sawdust was put in 10 clean and calibrated crucibles for each type of sawdust (specie and degree of torrefaction). These crucibles with sawdust were weighted before testing [27] and note this value as initial mass of sample. In order to protect the calciner oven, each sample with sawdust was burn over a gas flame up to no smoke was visible. Then, the crucibles were introduced inside of calciner at 650 °C and kept inside at least 2 hours. In the last hour from 10 in 10 minutes of calcination, the furnace door was opened to observe the calcination status. When the sparkling on the crucible is no longer visible and the ash has a grayish color it is considered that the calcination process is over. Then the crucibles are removed from the oven, cool in the desiccators and weigh the electronic balance with an accuracy of 0.001 g. This value represents the final mass of the ash crucible. With the mass values obtained during the test, the ash content (A_C) was calculated using the following calculation formula:

$$Ac = \frac{m_i - m_f}{m_i - m_c} \cdot 100\ [\%] \qquad (4)$$

Where: m_i is initial mass of sawdust with crucible, in g; mf-final mass of sawdust with crucible, in g; m_c-mass of crucible, in g.

The obtained results were statistically processed, using the upper and lower limit values, the arithmetic mean, as well as the average square deviation, all of these parameters being obtained under the conditions that the probability of acceptance of the results exceeds 95%. All results were validated with other statistical methods.

3. RESULTS & DISCUSSION

3.1. Pellet Density

Mass losses during the torrefaction process have led to a decrease in the density of the pellets obtained from this type of sawdust. For example, the density of the beech pellets dropped from 0.851 g cm^{-3} for non-torrefied pellets to 0.641 g cm^{-3} for the 210/3 regime of torrefaction (decrease of 24.6%), and the density of the spruce pellets dropped from 0.883 g cm^{-3} for non-torrefied pellets to 0.622 g cm^{-3} for the 210/3 regime of torrefaction (29.5% decrease). Density of currently wooden pellets from the market [11] had a higher density of 1.1 g cm^{-3} because these pellets are made on the industrial installations, more strength than that are used in laboratories. The decrease was differentiated on the intervals of the thermal treatment regime, as seen in Fig 3, as follows:

-for beech pellets, from non-torrefied pellets to 170/3 torrefaction regime the pellet density decreased by 16.4%, further to 190/3 thermal regime it decreased by 4.9%, and up to 210/3 thermal regime it decreased by 4.5%;

-for spruce pellets, from non-torrefied pellets to 170/3 torrefaction regime the pellet density decreased by 17.1%, further down to 190/3 thermal regime it decreased by 9.8%, and up to 210/3 thermal regime it decreased by 6.1%.

According to expectations, the density of the pellets dropped significantly but with insignificant values from one species to another and almost imperceptible differences within each torrefaction regimes. The maximum decrease percent of pellet density was obtained on torrefaction of 170 °C, followed by 190 °C (Fig 4), the same influence being for beech and spruce pellets.

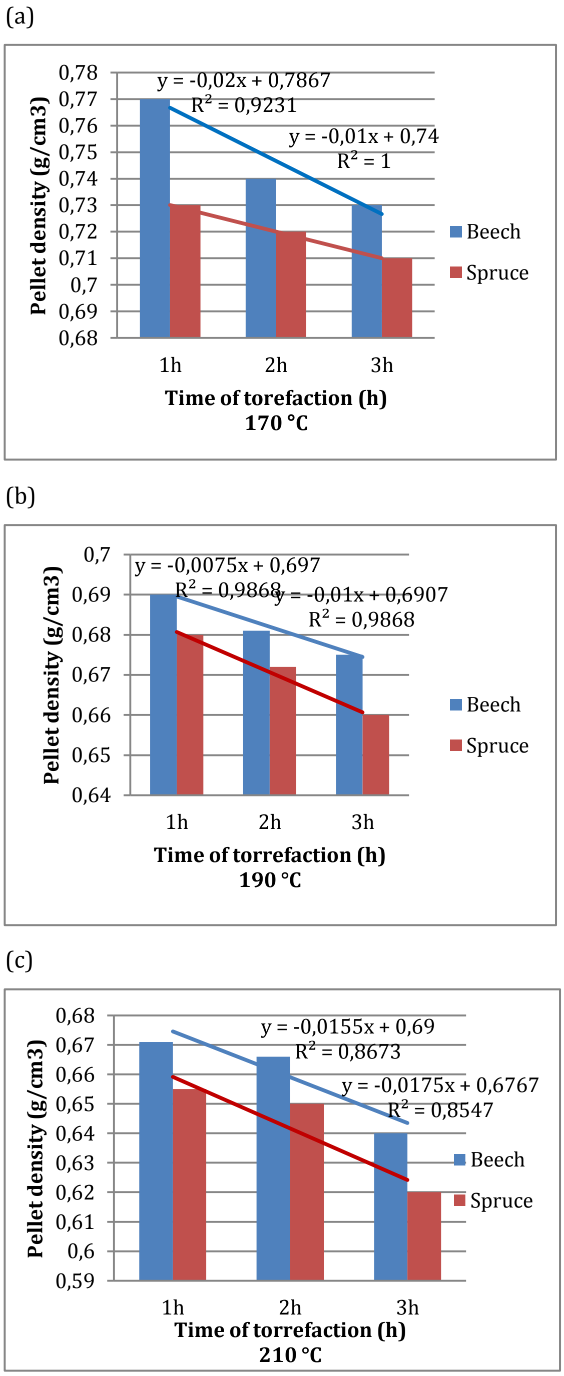


Fig 3. Density of torrefied pellets

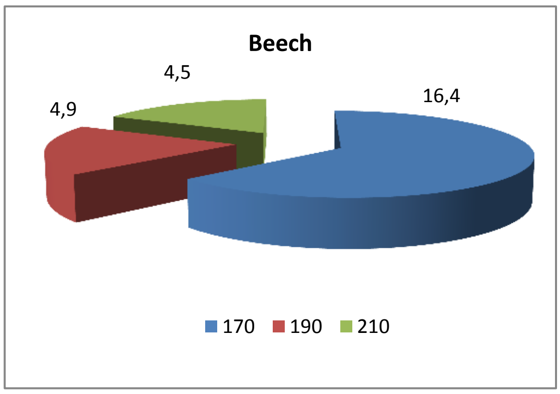


Fig 4. Decreasing in density related to torrefaction temperature for beech pellets

Another conclusion related to pellet density is that the density of beech pellets was higher than of spruce, because the density of beech specie was superior to that of spruce [11]. Because beech specie is a hard one the torrefaction process had a lower influence.

3.2. Calorific Value

There were obtained results for High Calorific Value (HCV) and Low Calorific Value (LCV) [28, 29]. As expected, the calorific power increased, due to carbonization of sawdust during torrefaction treatment. The maximum values of calorific value were determinate as 18976 kJ kg-1 for spruce and 19190 kJ kg-1 for beech pellets. Beyond these values, there were found the value of growth, differentiated by each regime of thermal treatment.

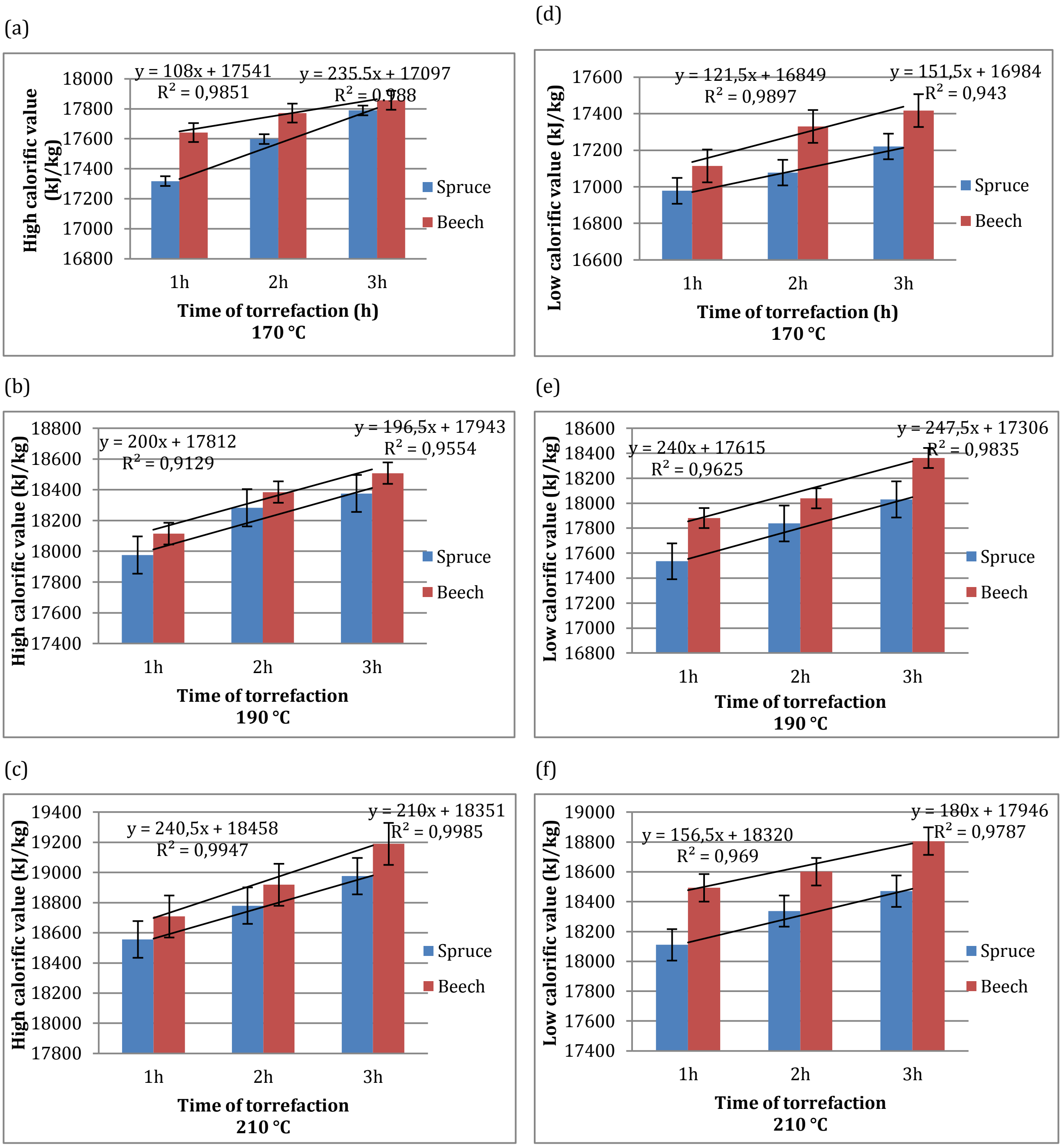


Fig 4. Calorific value of torrefied pellets

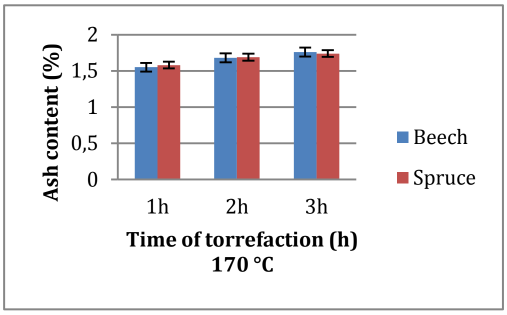
Total increase of calorific value was obtained for beech of 10.1% and 7.9% for spruce, to 95% probability of value accepting. This increase in calorific power is differentiated for thermal temperature as follows: for 170 °C the increase was of 3.7% for beech and 4.6% for spruce, for the temperature of 190 °C the increase was 4.5% for beech and 1.8% for spruce, and for the temperature of 210 °C the growth was of 2.6% for beech and 1.5% for spruce. It is clear that the temperature of 190 °C brought the highest increases in calorific value and the temperature of 210 °C brought the lowest increases, which means stopping the torrefaction treatment at 190 °C from the point of view of calorific value.

Taking charcoal as a comparison element with a specific calorific value of about 29300 kJ kg^{-1}, a high torrefaction reserve can be determined as 35.8%.

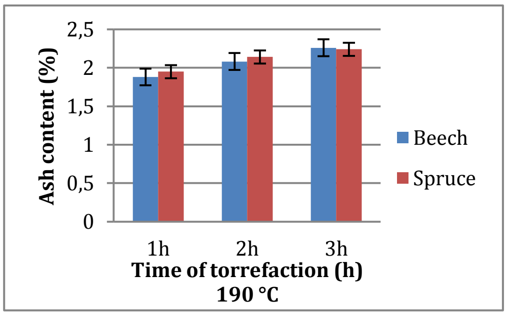
3.3. Ash Content

Minimal values of ash content were found for non-torefied sawdust, namely 1.48% for beech and 1.53% for spruce sawdust. Generally, the increase in the degree torrefaction of sawdust will increase proportionally with its ash content. This increase was 69.5% for beech sawdust and 65.3% for spruce. In regards with the ash contents increase in time of torrefaction process, when the beech pellets are taken into consideration, the maximum value is registered for the regime of 210/3 (2.51%), and the minimum value for the regime of 170/1 (1.55%). In case of the spruce pellets, the maximum value of the ash contents is registered for the regime of 210/3 hours (2.53%), and the minimum value for the regime of 170/1 hour (1.58%) (Fig 5).

(a)



(b)



(c)

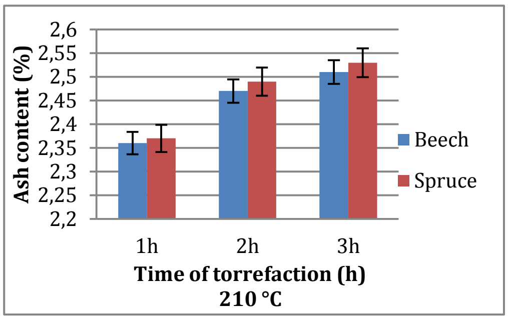
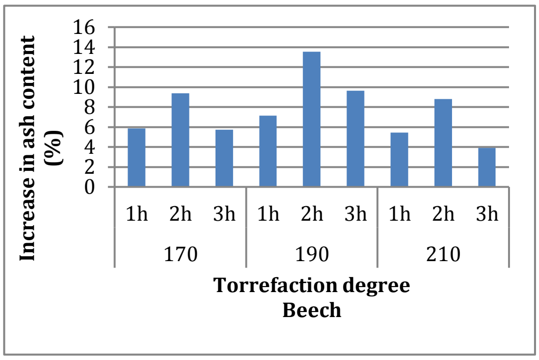


Fig 5. Variation of the ash contents for the two types of pellets, beech and spruce

Referring to the stages of beech sawdust torrefaction, if the whole interval of torrefied ash content is considered as unit (69.5%), this can be divided in three parts: part I, from control to 170 °C with 20.99%, part II, from 170 to 190 0C with 30.36%, and part III from 190 to 210 °C with 18.15%.

(a)



(b)

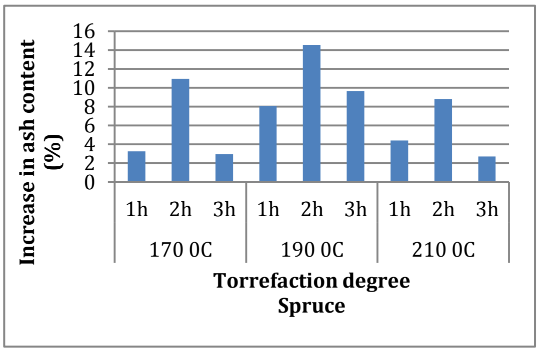


Fig 5. Increased percent of ash content related to torrefaction degree

Similarly, in the case of spruce sawdust the ash content growth range (65.3%) is divided into three parts: part I with 17.16%, part II with 32.24% and part III with 15.9%. Even if the values are little different from one species to another, the conclusions are clear: the temperature of 190 °C had the most influence of the ash content increase, and inside of the same temperature the strongest influence was the second hour. Taking into account that the term of comparison in this case is charcoal with an ash content of about 34% [30, 31], it is observed that there was a huge torrefaction reserve of about 2360%.

4. CONCLUSIONS

Beech and spruce sawdust were chosen for this research because these species are representative for hard and soft species. Sawdust is a kind of biomass as one of the oldest fuel materials, this way being fulfilled the protection of the environment. The torrefaction process in the range of 170-210 °C temperature, for 1, 2, and 3 hours has brought benefits particularly in terms of calorific value with a total increase of 10.1% for beech and 7.9% for spruce. Correlated with the decrease of pellet densities (with 24.6% for beech and 29.5% for spruce) the benefits are amplified and 1 bag of 10 kg will have more and better material. The temperature of 190 °C was the most one when the calorific value and ash content is taken into consideration. The maximum value of the superior calorific value of pellets were registered for the 210/3 regime with a value of 19 190 kJ kg^{-1} for beech and 18976 kJ kg^{-1} for spruce. Ash content of torrefied sawdust increased in time of thermal treatment with 69.5% for beech sawdust and 65.3% for spruce, with a large reserve vs. charcoal.

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RESEARCH ARTICLE

Solid waste management in non-state armed group-controlled areas of Syria case study "Daret Azza and Atareb sub-district"

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ABSTRACT

The purpose of this study (technical assessment) is to understand the effect of the Syrian crisis on the solid waste management (SWM) sector in Non-State Armed Group (NSAG) controlled areas and define the worst communities located in Daret Azza and Atareb subdistrict (DAAS)/Aleppo governorate of Syria. The assessment showed that: SWM sector in general is not supported from Non-governmental organizations (NGOs) in a good way so the environment is polluted and cutaneous leishmaniasis registered cases increased and a huge number of the cases were registered during the fourth months of 2018. The number of communities of DAAS is forty and the population is about 275740 persons (of them 110016 internal displaced persons (IDPs)) live in it, all these local councils do not receive or supported by SW equipment, tools and machines, The SWM of Majbineh, Balenta, Bshantara, Bishqatine, Mezanaz, Arnaz, Qanater, Western Kafr Jum and Arhab is considered the worst in DAAS. The total volume of MSW production of DAAS is 386.72 m^3 day^{-1} and the total quantity is 77344 kg day^{-1} and the average value SW production per capita for DAAS is : 0.28 kg day^{-1}, All the landfills of DAAS are not sanitary and could be considered a randomly dumps. The maximum Cutaneous leishmaniasis cases are at Western Kafr Jum: 738 cases in the fourth months of the 2018 year, which is considered so risky, the root cause of this case related to the bad SWM.

Keywords: Atareb, Daret Azza, solid waste, The Syrian crisis

1. INTRODUCTION

Environmental pollution has affected the human world since early times and is still growing due to excessive growth in developing countries. Municipal solid waste (MSW) normally is a product of human activities [1]. MSW is usually generated from human settlements, small industries, and commercial activities. Solid waste generation is a natural phenomenon and the amount of waste produced is directly proportional to population growth. Less population means less quantity of MSW [2], Also MSW is usually considered as the waste that is generated from human settlements, small industries, commercial and municipal activities [2] the general sources of MSW are showed in Table 1.

The amount of MSW in a region is not only a function of the living standard, but also the lifestyle and socioeconomic status of the residents living there [4]. Though solid waste management (SWM) is one of the mandatory functions for improvement of urban lifestyle [5], An integrated SWM is one of the major challenges for sustainable development [6].

Municipal solid waste management (MSWM) projects are intended to contribute to livelihoods stabilization through the creation of temporary employment opportunities as well as environmentally and economically sustainable livelihoods opportunities for crisis-affected men and women. This is not just a livelihood intervention; it also strengthens the service delivery of the local governments and works towards fostering the relationship between the State and society [7].

In developing countries such as Syria open randomly dumpsites are common, because of the low budget for waste disposal. It also could be a serious threat to groundwater resources and soil, the contamination of soil by heavy metal can cause adverse effects on human health, animals and soil productivity [8, 9]. The Syrian conflict has enveloped the entire country

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and led to mass-scale destruction at all levels of society: socially, economically and civilly. The conflict has led to one of the worst humanitarian crises of modern history, leaving an impact on the most vulnerable populations of women and children. Basic services are no longer operating, thereby multiplying the suffering Syrians continue to face daily [10].

Table 1. The general sources of MSW [2]

Source	Activities, typical amenities, or locations where wastes are generated	Types of SW
Residential	Single-family and multi-family home, low, medium, and high-rise apartments, etc.	Food wastes, rubbish, paper waste, ashes, special wastes.
Commercial and institutional	Warehouses, restaurants, markets, office buildings, hotels, shopping malls, schools, print shops, auto repair shops, medical facilities and institutions, prisons.	Food wastes, rubbish, ashes, demolition and construction wastes, special wastes, occasionally hazardous wastes.
Open areas	Streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas, marriage halls, etc.	Street sweepings, roadside litter, rubbish, and other special wastes.
Treatment plant sites	Water, sewage and industrial waste water treatment processes.	Treatment plant sludges.

SWM systems in Syria are overloaded with the high influx of internally displaced persons (IDPs) destruction and/or damages of basic infrastructure [11], and the equipment and heavy machinery normally used for SWM are often looted, destroyed, and not functioning due to the need of new spare parts and maintenance. This contributes to large amounts of garbage piled up in the streets, deteriorating the environmental and health situation and further exacerbating difficult living conditions [11].

At NSAG controlled areas of Syria, the local councils which are because a local authority, these local councils always face difficulties during their work due to lack of the fund, and the main resource of their fund is a grant from local and international NGOs especially which have registration in Turkey, SWM services are primarily provided by local authorities in most parts of Syria and usually provide a basic level of service. However, due to the lack of comprehensive disposal strategies and operational challenges, efforts are needed in specific rural and urban communities to strengthen and upgrade the quality and regularity of solid waste collection (SWC) [10].

Before the start of conflict in Syria in 2011, nearly 80% of population in Syria were served by well-developed, state-owned, centrally-managed SWM which related to ministry of local administration and environment, the municipality of each village, town, and city is responsible for SWM, The solid waste collection (SWC) method were assessed in 2017 by the collaborative effort of the Whole of Syria coordination team, water, sanitation and hygiene (WASH) partners, From Syria, Turkey, Jordan, Iraq and Lebanon Humanitarian Hubs [12], Table2 showed collection methods and its percentage for Atareb and Daret Azza subdistrict [12].

The MSW of Syria contains a large component of organic matter so it could be a resource for producing a compost an example is MSW of Aleppo city which contain 58% organic matter as showed in the Table (3) [13].

Table 2. Solid waste collection methods and its percentage of Atareb and Daret Azza subdistrict

Subdistrict	Solid waste disposed of household to a dumping location	Solid waste left in public areas	Public solid waste collection free
Atareb	7.36%	2.11%	90.53%
Daret Azza	0.00%	0.00%	100%

Table 3. The average percentage of MSW in Aleppo city

Organic matter	Plastic and rubber	Papers	soil	Metals	Glass	wood	Other
58%	14%	13%	0%	1%	7%	4%	4%

The author hopes from this research to give a deep understanding about the situation of SWM in the NSAG controlled areas of Syria, these areas suffer from the lack of financial resources to conduct a good SWM, the goals of this research are:

1-Determine the amount of the solid waste generated in the NSAG controlled areas of Syria, a case study "Daret Azza and Atareb sub-district which located in Aleppo governorate.

2-Determine the quantity and the volume of MSW of some communities of Daret Azza and Atareb subdistrict.

3-Determine the urgent needs and the budget for SWM of Daret Azza and Atareb subdistrict.

4-Get a deep understanding about SWM of Non-State Armed Group (NSAG) controlled areas of Syria.

2. MATERIALS AND METHOD

This research focuses on DAAS which located on Jebel Saman district at Aleppo governorate of Syria as showed in Fig 1, which is located in NSAG-controlled areas since the end of 2012. the total number of populations is about 109612 persons (50942 IDPs, 58670 local people) in Daret Azza, and Atareb 166128 (59074 IDPs, 107054 local people) as showed in Table 4 [14], According to Assistance Coordination Unit (ACU) reports: during the first fourth months of 2018 the number of Cutaneous leishmaniasis registered cases were: 1583 at Atareb and, 422 at Daret AZZA subdistrict [15]. Fig 2 showed some pics of SWM of Daret Azza and Atareb subdistrict.

Fig 1. Aleppo governorate and Daret Azza and Atareb subdistrict location (yellow color)

Syrian Engineers for Construction and Development (SECD) conducted a WASH response for IDPs in the north of Syria, during this response SECD team conducted a deep technical assessment for solid waste services sector at the communities of Atareb and Daret Azza using questioners, and physical measures in the field. The assessment was conducted by the author and ten technical engineers from SECD team in addition to thirty-nine local councils of the targeted area are involved in the study.

The SW system of DAAS as all other subdistricts of Syria consists of the following parts: SWC

1) SW containers.
2) Tractors with a trailer for solid waste collection (SWC).
3) SW compactor which is used only in big cities.
4) Randomly open dump for final disposal of SW.

All communities of DAAS use tractor with a trailer for SWC and also only two communities use Solid waste compactor in addition to the tractors with trailers.

Fig 2. Some pics of SWM of Daret Azza and Atareb subdistrict

3. RESULTS AND DISCUSSION

The technical and need assessments were conducted by the author and SECD team during March and April of 2018 for SW system for all the communities which located in DAAS. The results of the assessment are shown in Tables 5, 6, 7, 8, 9 and Table 10.

Table 4. The total number of populations of Daret Azza subdistrict communities

District	Sub- district	Community	Population
Jebel saman	Daret Azza	Hur	3474
Jebel saman	Daret Azza	Tqad	8067
Jebel saman	Daret Azza	Arhab	3359
Jebel saman	Daret Azza	Majbineh	2674
Jebel saman	Daret Azza	Bsartun	5500
Jebel saman	Daret Azza	Anjara	12754
Jebel saman	Daret Azza	Zarzita	4030
Jebel saman	Daret Azza	Hoteh	8384
Jebel saman	Daret Azza	Bshantara	1265
Jebel saman	Daret Azza	Bishqatine	1174
Jebel saman	Daret Azza	Kafrantin	225
Jebel saman	Daret Azza	Qabtan Eljabal	4811
Jebel saman	Daret Azza	Daret Azza	43320
Jebel saman	Daret Azza	Deir Saman	7000
Jebel saman	Atareb	Balenta	3575
Jebel saman	Atareb	Mezanaz	2,604
Jebel saman	Atareb	Halazon	2,124
Jebel saman	Atareb	Arnaz	740
Jebel saman	Atareb	Sheikh Ali	4,863
Jebel saman	Atareb	Qanater	2,189
Jebel saman	Atareb	Little Orm	2,086
Jebel saman	Atareb	Babka	3,385
Jebel saman	Atareb	Tadil	2,921
Jebel saman	Atareb	Maaret Atarib	3,975
Jebel saman	Atareb	Abin Samaan	9,028
Jebel saman	Atareb	Jeineh	7,053
Jebel saman	Atareb	Western Kafr Jum	4,502
Jebel saman	Atareb	Kafr Amma	3,980
Jebel saman	Atareb	Kafr Naseh Elatareb	4,903
Jebel saman	Atareb	Kafr Taal	6,061
Jebel saman	Atareb	Kafr Thoran	6,840
Jebel saman	Atareb	Tuwama	6,996
Jebel saman	Atareb	Sahara	6,856
Jebel saman	Atareb	Batbu	8,050
Jebel saman	Atareb	Big Orm	5,820
Jebel saman	Atareb	Abzemo	8,781
Jebel saman	Atareb	Oweijel	6,001
Jebel saman	Atareb	Kafr Aleppo	8,790
Jebel saman	Atareb	Kafr Karmin	7,980
Jebel saman	Atareb	Atareb	27,298
Jebel saman	Atareb	Kafr Naha	12,302
Total			275740

Table 5. The Availability of instruments and machines of SWM of the communities of DAAS

Community	Number of workers	Number of tractors with trails	Number of SW container	A Volume of a SW container (m3)	Number of SW compactor
Hur	3	1	0	0	0
Tqad	12	1	20	1	0
Arhab	0	0	0	0	0
Majbineh	4	0	20	0.5	0
Bsartun	6	1	25	1	0
Anjara	20	4	100	1	1
Zarzita	0	1	0	0	0
Hoteh	5	1	50	1	0
Bshantara	0	0	0	0	0
Bishqatine	0	0	30	0.5	0
Kafrantin	4	1	8	1.5	0
Qabtan aljabal	6	2	0	0	0
Daret Azza	27	2	80	2	2
Deir Saman	5	1	2	2	0
Balenta	3	0	0	0	0
Mezanaz	0	0	0	0	0
Halazon	5	1	0	0	0
Arnaz	0	0	0	0	0
Sheikh Ali	3	1	0	0	0
Qanater	0	0	0	0	0
Little Orm	10	1	0	0	0
Babka	6	1	0	0	0
Tadil	4	1	0	0	0
Maaret tarib	5	1	0	0	0
Abin Samaan	6	1	0	0	0
Jeineh	10	1	0	0	0
Western Kafr Jum	0	0	0	0	0
Kafr Amma	5	1	0	0	0
Kafr Naseh Elatareb	5	1	0	0	0
Kafr Taal	10	1	3	0.25	0
Kafr Thoran	15	2	0	0	0
Tuwama	5	1	200	0.1	0
Sahara	6	1	0	0	0
Batbu	12	2	200	0.2	0
Big Orm	12	2	0	0	0
Abzemo	13	1	80	0.1	0
Oweijel	5	1	10	0.25	0
Kafr Aleppo	4	1	0	0	0
Kafr Karmin	15	2	0	0	0
Atareb	40	3	200	0.6-1	2
Kafr Naha	6	2	0	0	0

Table 6. The Availability of support for SWM of of the communities of DAAS

Community	Availability of support		
	Salaries for workers	Fuel for SW vehicle	Equipment and stationaries
Hur	0	Yes	0
Tqad	0	Yes	0
Arhab	0	0	0
Majbineh	0	0	0
Bsartun	0	0	0
Anjara	Yes	Yes	0
Zarzita	0	Yes	0
Hoteh	0	0	0
Bshantara	0	0	0
Bishqatine	0	0	0
Kafrantin	0	0	0
Qabtan Eljabal	0	Yes	0
Daret Azza	0	Yes	0
Deir Saman	0	Yes	0
Balenta	0	0	0
Mezanaz	0	0	0
Halazon	0	0	0
Arnaz	0	0	0
Sheikh Ali	0	Yes	0
Qanater	0	Yes	0
Little Orm	Yes	0	0
Babka	Yes	0	0
Tadil	Yes	0	0
Maaret Atarib	Yes	0	0
Abin Samaan	0	0	0
Jeineh	0	Yes	0
Western Kafr Jum	0	0	0
Kafr Amma	0	0	0
Kafr Naseh Elatareb	0	0	0
Kafr Taal	0	Yes	0
Kafr Thoran	0	0	0
Tuwama	0	0	0
Sahara	0	Yes	0
Batbu	Yes	0	0
Big Orm	Yes	0	0
Abzemo	Yes	Yes	0
Oweijel	0	Yes	0
Kafr Aleppo	0	Yes	0
Kafr Karmin	Yes	Yes	0
Atareb	Yes	0	0
Kafr Naha	0	0	0

Table 7. The SWC methods of the communities of DAAS

Community	SW disposed of by household to a dumping location	% SW amount left in public areas without collection and disposal (%)	% SW collection free by the local council (%)
Hur	0	0	100%
Tqad	0	0%	100%
Arhab	0	34%	66%
Majbineh	0	26%	74%
Bsartun	0	0	100%
Anjara	0	0	100%
Zarzita	0	0	100%
Hoteh	0	0	100%
Bshantara	0	25%	75%
Bishqatine	0	0	100%
Kafrantin	0	0	100%
Qabtan Eljabal	0	0	100%
Daret Azza	0	0	100%
Deir Saman	0	0	100%
Balenta	0	0	100%
Mezanaz	0	36%	64%
Halazon	0	0	100%
Arnaz	0	0	100%
Sheikh Ali	0	0	100%
Qanater	0	0	100%
Little Orm	0	50%	50%
Babka	0	0	100%
Tadil	0	0	100%
Maaret Atarib	0	0	100%
Abin Samaan	0	0	100%
Jeineh	0	0	100%
Western Kafr Jum	0	0	100%
Kafr Amma	0	0	100%
Kafr Naseh Elatareb	0	0	100%
Kafr Taal	0	0	100%
Kafr Thoran	0	0	100%
Tuwama	0	0	100%
Sahara	0	0	100%
Batbu	0	0	100%
Big Orm	0	0	100%
Abzemo	0	0	100%
Oweijel	0	0	100%
Kafr Aleppo	0	0	100%
Kafr Karmin	0	0	100%
Atareb	0	0	100%

Table 8. The solid waste collection frequency (SWCF) of the communities of DAAS

Community	(SWCF)		
	More than 3 times per week	Once a week	Once every two weeks or more
Hur	Yes	0	0
Tqad	Yes	0	0
Arhab	0	Yes	0
Majbineh	0	Yes	0
Bsartun	Yes	0	0
Anjara	Yes	0	0
Zarzita	Yes	0	0
Hoteh	Yes	0	0
Bshantara	0	Yes	0
Bishqatine	0	Yes	0
Kafrantin	Yes	0	0
Qabtan Eljabal	Yes	0	0
Daret Azza	Yes	0	0
Deir Saman	Yes	0	0
Balenta	0	Yes	0
Mezanaz	0	0	Yes
Halazon	Yes	0	0
Arnaz	0	0	Yes
Sheikh Ali	Yes	0	0
Qanater	0	0	Yes
Little Orm	Yes	0	0
Babka	Yes	0	0
Tadil	Yes	0	0
Maaret Atarib	Yes	0	0
Abin Samaan	Yes	0	0
Jeineh	Yes	0	0
Western Kafr Jum	0	0	Yes
Kafr Amma	0	Yes	0
Kafr Naseh Elatareb	Yes	0	0
Kafr Taal	Yes	0	0
Kafr Thoran	Yes	0	0
Tuwama	0	Yes	0
Sahara	Yes	0	0
Batbu	Yes	0	0
Big Orm	Yes	0	0
Abzemo	Yes	0	0
Oweijel	Yes	0	0
Kafr Aleppo	Yes	0	0
Kafr Karmin	Yes	0	0
Atareb	Yes	0	0
Kafr Naha	Yes	0	0

Table 9. The quantity, the volume of SW of the communities of DAAS

Community	MSW production (m^3 day^{-1})	Quantity of MSW (kg day^{-1})	Quantity of MSW (kg cap^{-1} day^{-1})
Hur	5.4	1080	0.31
Tqad	9.9	1980	0.25
Arhab	3	600	0.18
Majbineh	2.95	590	0.22
Bsartun	5	1000	0.18
Anjara	14.5	2900	0.23
Zarzita	7.9	1580	0.39
Hoteh	6.1	1220	0.15
Bshantara	3.8	760	0.60
Bishqatine	3	600	0.51
Kafrantin	0.7	140	0.62
Qabtan Eljabal	11.8	2360	0.49
Daret Azza	100	20000	0.46
Deir Saman	6.9	1380	0.20
Balenta	2	400	0.11
Mezanaz	2.85	570	0.22
Halazon	2.13	426	0.20
Arnaz	0.48	96	0.13
Sheikh Ali	2.93	586	0.12
Qanater	1.1	220	0.10
Little Orm	2.45	490	0.23
Babka	2.95	590	0.17
Tadil	2.91	582	0.20
Maaret Atarib	7.89	1578	0.40
Abin Samaan	11.2	2240	0.25
Jeineh	11.7	2340	0.33
Western Kafr Jum	2.2	440	0.10
Kafr Amma	2.6	520	0.13
Kafr Naseh Elatareb	4.9	980	0.20
Kafr Taal	9.8	1960	0.32
Kafr Thoran	5.61	1122	0.16
Tuwama	8.1	1620	0.23
Sahara	9.9	1980	0.29
Batbu	9.2	1840	0.23
Big Orm	17	3400	0.58
Abzemo	14.3	2860	0.33
Oweijel	4.8	960	0.16
Kafr Aleppo	9.89	1978	0.23
Kafr Karmin	24.3	4860	0.61
Atareb	21.2	4240	0.16
Kafr Naha	11.38	2276	0.19

Table 10. The distance between the center community and the nearest landfill, and Cutaneous leishmaniasis cases of the communities of DAAS

Community	The distance between the center of community and nearest the landfill (km)	Registered Cutaneous leishmaniasis cases during 2018 (ACU, EWARN 2018)
Hur	2	15
Tqad	1.5	33
Arhab	2	NA
Majbineh	3	NA
Bsartun	1	N/A
Anjara	2	194
Zarzita	3	N/A
Hoteh	2	N/A
Bshantara	2	N/A
Bishqatine	4.5	N/A
Kafrantin	10	N/A
Qabtan Eljabal	2	101
Daret Azza	9	79
Deir Saman	8	N/A
Balenta	12	N/A
Mezanaz	1.5	2
Halazon	3	N/A
Arnaz	1	N/A
Sheikh Ali	2	49
Qanater	0.2	N/A
Little Orm	0.5	N/A
Babka	6	N/A
Tadil	2	N/A
Maaret Atarib	2	N/A
Abin Samaan	4	424
Jeineh	1	175
Western Kafr Jum	1	738
Kafr Amma	2	N/A
Kafr Naseh Elatareb	10	N/A
Kafr Taal	2	52
Kafr Thoran	5	20
Tuwama	1	N/A
Sahara	2	42
Batbu	2	N/A
Big Orm	1.5	0
Abzemo	2	45
Oweijel	2.5	N/A
Kafr Aleppo	1	N/A
Kafr Karmin	0.8	31
Atareb	4	5
Kafr Naha	2	N/A

1- About twenty-six communities (123455 persons) of DAAS do not have SW containers which are necessary for SWC, this is considered an evidence of the bad state of SWM, local councils do not have enough resources for buying SW containers, the cost of each one is about 70 $ with capacity 0.5 m^3 that can serve 200-300 persons.

2- The number of local councils DAAS is forty, and all these local councils do not receive or supported by SW equipment, tools and machines, and only fourteen local councils (hosted 105407 persons) supported by salaries for the worker of SWM from NGOs, this support is not sustainable, also only 16 local councils (hosted 142030 persons) supported by fuel from SECD for SW vehicles this support also is not sustainable it is an emergency support only for 3months. In general SW sector is not supported from NGOs in a good way so the environment is polluted and cutaneous leishmaniasis registered cases increased and a huge number of it was registered during the fourth months of 2018 [13].

3-The SWM of Balenta, Majbineh, Bshantara, Bishqatine, Mezanaz, Arnaz, Qanater, Western Kafr Jum and Arhab is considered so bad because these local councils do not have tractors with trailers for SWC and do not have dedicated workers for SWC and disposal, also SWCF is Once per a week which considered is too low, in emergency conditions the SWCF must be at least two times per a week [16].

4- The local council of DAAS conducts SW as public free because 85% of the people inside Syria live under the line of poverty and do not have enough resources.

5-SWCF values differ from one community to other, the SWCF of 30 communities is at least 3 times per week which hosted 242682 persons (88.01% of total people live at DAAS), and once week of 7 communities which hosted 23023 persons (8.35% of total people live at DAAS) and Once every two weeks or more of 4 communities (Mezanaz, Arnaz, Qanater and Western Kafr Jum) (10035 persons 3.64%) (of total people lives at DAAS) as shown in the Fig 3 and the Fig 4, before the crisis of Syria at 2011, The SWC was performed daily by the local council, the SWCF once per a week consider is low, it must be at least two times per a week in the crisis [16].

6-Most of the local councils DAAS do not have enough support for conducting SWM so

the registered cutaneous leishmaniasis cases of these subdistricts are so big.

7-The total volume of MSW production of DAAS is 380.5 m3 day^{-1} and the total quantity is 76100 kg day^{-1}. The average, maximum and minimum of SW production per capita at DAAS communities is (1.36, 3.11, 0.49) L day^{-1} and (0.27, 0.62, 0.1) kg day^{-1} and the average SW production per capita value for DAAS is: 1.42 L day^{-1}, 0.28 kg day^{-1}, these values are similar to the value recognized by the world bank [17]. It is known that the amount of solid waste changes depending on the economical and cultural living conditions and also seasonal changes [18]. It is highly recommended to establish a general management of solid waste for DAAS to achieve a 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 useful products, such used rubber tire pyrolysis of waste tire rubber to produce liquid fuel. [19], recycling of waste plastics for utilization it as an energy source [20] and Biodiesel production from waste oils [21].

8-There are 24 random landfills of DAAS. which considered a spot of pollution, resources of bad odors and one of the roots causes of cutaneous leishmaniasis, in other hand the average, maximum and minimum distances between the center of the community and the nearest random landfill are (2.9, 12, 0.2) km respectively, it is highly recommended that only one or two sanitary landfills be conducted for DAAS instead of 24 random landfills.

9-The maximum Cutaneous leishmaniasis cases is at Western Kafr Jum: 738 cases in the fourth months of the 2018 year [13], which is considered so big, the route causes of this issue are: solid waste containers are not available, there are not dedicated workers for SWC and disposal, and the solid waste collection is conducted one time per week , So Western kafr jum need urgent assistances to establish strong solid waste management .

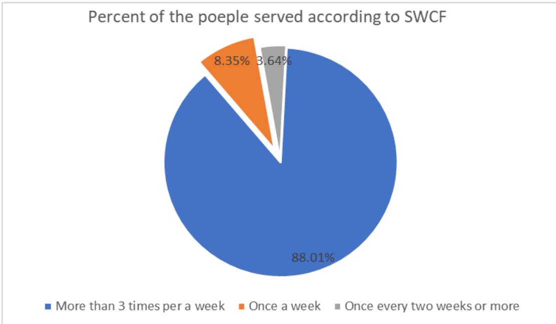

Fig 3. Percent of served people according to SWCF

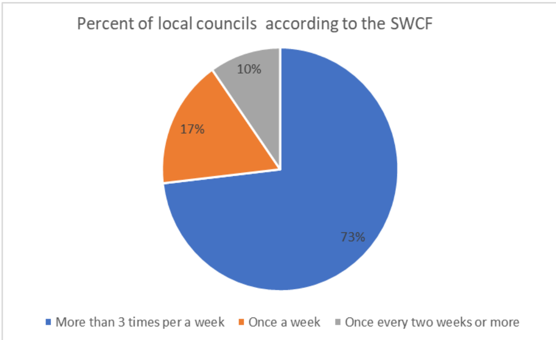

Fig 4. Percent of the local councils and people served according to SWCF

4. CONCLUSIONS

The SWM management of NSAG controlled areas considered very bad because of the shortage of financial resources, so the environment polluted and the cutaneous leishmaniasis increases day by day. The local councils of NSAG area need urgent support and training for operation SWM in a good way. Effective SWC will reduce the cutaneous leishmaniasis cases and the pollution of the environment.

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CONFERENCE PAPER

Integrated study of building information modeling (BIM) with green buildings for a sustainable environment

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ABSTRACT

This study emphasizes the necessity of sustainable buildings in order to protect environmental resources and reduce pollution by using technological developments. With the building information modeling, which is one of the contributions of developing technology, a three-dimensional simulation of a building project can be created. The annual energy and carbon emissions of the building can be calculated by means of analysis tools. Within the scope of the study, it is emphasized that the effects of carbon emissions on window thickness, window wall ratio, and window shades can be predicted by using Building Information Modeling analysis tools.

Keywords: Sustainability, building information modeling (BIM), green BIM, carbon emissions

1. INTRODUCTION

With the arrival of new technology, growing income The ideas that accompanied by the technological developments that started with the Industrial Revolution, after World War II, have been put into practice worldwide to meet the rising needs with rapid population growth and rapid economic development plans. This unplanned urbanization, which is not aimed at protecting the natural environment as a result of the industrialization, has led to the gradual decline of the green area, the increase in the per capita energy demand, the unconscious consumption of limited natural resources and the intensive use of oil resources. These environmental effects prevailed at the local level have reached global dimensions as a result of the imbalance between production and consumption.

The concept of "Sustainability" was first described in the Brundtland Report published by the United Nations Environment and Development Commission in 1989. Recent developments have emerged in many branches of the industry to support this concept. The application of environment and energy policies that support economic development that does not threaten natural life in the societies forces the state, institutions, foundation and business community, non-governmental organizations and other stakeholders to behave in this way. Therefore, as a result of its sustainable policies the construction sector, which is a part of new developments, has created a sustainable architecture, which is responsible for the pollution of natural resources and environmental pollution and at the same time environmentally friendly.

In this study, in order to reduce the effects of climate change caused by greenhouse gases, the effects of window thickness, window wall ratio and window shades on carbon emissions are investigated by subjecting the 3D simulation of a sample building project to energy analysis. In this way, it is aimed to reduce possible time losses and risks [1, 3].

2. MATERIALS AND METHOD

2.1. Sustainability

Sustainability in general; It is defined as maintaining the ability to be permanent while ensuring the continuity of diversity and productivity. In this context, the idea of sustainability should be implemented in all areas from global development

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policy to the use of energy resources and from production planning to architectural designs.
In the consumer society, the adoption of sustainable development strategies is important for future investments aimed at economic solutions and caring about environmental management. From this perspective, it can be stated that sustainability has three main components: environmental, economic and societal. Between the environmental, economic and social components of sustainability, by creating a balanced synergy and by providing a strategic development these three components should be considered as integral parts of the whole [1, 4].

Environmental Sustainability: Environmental sustainability means protecting the world from destroying ecological equilibrium and natural systems in order to offer the world better conditions for future generations. The basic step of this protection situation is the delivery of natural resources without destruction. Therefore, while determining the level of use of natural resources; these sources need to be taken into account for the cleaning of these sources and for the removal of pollutants.

Environmental sustainability is sensitive to the following issues;

•Preservation of vitality and diversity in the world,

•Protection of life support systems,

•Sustainable use of renewable resources,

•Saving by using non-renewable resources,

•To minimize the harm to the environment and living things,

•Protection of cultural and historical environments [4]

Economic Sustainability: The strategy adopted by today's the modern economic development model is that the economic activities will increase in the market with the increase of the purchasing power of the individuals and thus the increase of the Gross National Product will contribute to society. This development model, targeting unlimited consumption, brings to the agenda environmental problems with the wastes that are generated at the end of the consumption madness. Economic sustainability aims to provide a steady flow of investment with the effective use and management of resources, taking ecological sensitivities into account.

Economic sustainability is sensitive to the following issues;

•Creation of new markets and trade opportunities

•Reducing energy and resource input in production, thus reducing costs with efficiency

•Providing added value [4]

Social Sustainability: Social sustainability focuses on some fundamental rights and freedoms of people. The most obvious of these fundamental rights and freedoms are equality and balance between generations. Sources are passed down to new generations to maintain their assets and ensure their assets.

Social sustainability is sensitive to the following issues;

•Ensuring that each individual has long-term basic needs such as work, health conditions, education and cultural activities

•Increasing the quality of life

•Rehabilitation of disabled groups

•Protecting the right to life of future generations [4]

2.1.1. Sustainable Development Strategies

Sustainable development strategies are based on nine basic principles, starting from the idea of "the increase in people's quality of life provided that the limited ecosystem remains within the bounds of transport capacity".

•Respect and attention to social life

•Increasing the quality of life of people

•Protection of vitality and diversity in the World

•Reduction of non-renewable resource consumption

•The carrying capacity of the earth should not exceeded

•Demonstrate change in individual behaviors and habits

•Respect for the environment by societies

•Establishing a national framework for integration between development and protection

•Establishing world-wide treaty on sustainability at global scale [2, 3]

2.1.2. Sustainability in the Construction Sector

It is known that the executive part of the construction sector is at the forefront while sustainable development strategies are being developed. Today, the construction sector has an important place both in the economy and employment. Besides the mines such as iron, cement and aluminum which are used during construction, and maintenance and repair of the building; such as water, natural gas and coal, which are used in the construction of the building, are the main sources of natural resources used in the construction sector. In addition, the sustainable construction sector is necessary for sustainable development, as there are many environmental problems during the destruction process.

As the human population in the constantly developing world increases, the number of buildings needed is also rising. As a result of this situation, energy and resource consumption in excess of the buildings caused a number of adverse effects on climate change and air and water quality in cities. In this context, air pollution is 23%, water pollution is 40%, solid pollution is 40% and the pollution caused by greenhouse gas production is 50% [5].

Sustainable Architecture: Sustainable architecture is defined as a group of activities that minimizes the harm to the environment, ensures the ecological balance and uses the required construction process. On the other hand, energy, water, and materials are the main sources of the main inputs for construction. The principles of sustainable architecture are based on the protection of these basic inputs [5].

Sustainable Construction: Sustainable construction is the implementation of all sustainable development principles, such as building life cycle, raw material production, construction material disposal, disposal, and waste management planning. The main purpose of sustainable construction is to establish the appropriate settlements for people and to ensure harmony between nature and environment by supporting economic equality. In addition to the construction process, large amounts of resources are required to be used during the disposal of the wastes that occur during both the service period and maintenance-repair activities. The controlled use of these resources is among the main objectives of sustainable construction.

In order to ensure sustainability in the pre-construction phase, the land should be used efficiently, sustainable-flexible building designs should be supported and effective material selection should be made. During the construction phase, efficient waste management should be adopted and energy efficient materials should be used to ensure sustainability. In the post-construction phase, existing structures should be adapted to new users and programs, building elements and materials should be reused, building components and materials should be recycled and land and existing infrastructure should be reused [4, 5].

2.2. Building Information Modeling (BIM)

Building Information Modeling is an information sharing process. Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. It is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct and manage buildings and infrastructure. Due to the dynamic system, a possible change between stakeholders can be updated immediately, resulting in better quality project outputs and possible risks being reduced in a shorter period of time. BIM not only provides technical advantages to the development process, but it also provides an innovative and integrated work platform for increasing productivity and sustainability throughout the project life cycle.

BIM supports social sustainability in two key areas. Firstly, it provides a better facility design for comfort of life in society and it allows the designers to review while they are still in the design phase and give feedback through the visulization of a three-dimensional building information mode. Secondly, it promotes the achievement of more absolute results by providing a better framework of cooperation that will strangthen the working relationship between project participants [3, 5].

2.2.1. Objectives of Building Information Modeling (BIM)

In the direction of the objectives determined by the building information modeling, it is necessary to make visualization, cost estimation, construction sequencing, conflict analysis and neutral analysis, facility management, prediction of environmental data, determination of life cycle data, faster and more efficient processes, better design possibilities and better customer service are presented [3, 5].

2.2.2. Uses of Building Information Modeling (BIM)

Usage areas of building information model; engineering, energy, static, lighting, mechanical, site, structural system analysis; phase planning (4B Modeling), programming, cost estimation - discovery (5B Modeling), sustainability assessment, digital manufacturing, 3D control and planning, visualization, design creation and development, 3D coordination, site use planning, construction system design-, building management and maintenance (7B Modeling), asset management, space planning and follow-up, disaster planning and planning of existing resources [3, 5].

2.2.3. Benefits of Building Information Modeling (BIM)

•By means of the improved construction documentation, drawing mistakes can be reduced during the design and construction phases.

•Numerous design alternatives can be created and tested.

•The project can be managed more effectively.

•Cost estimates and timing are continuously updated to yield more reliable results.

•Business and plant management data are transferred automatically.

•Having to real-time clash detection, coordination and knowledge management, site coordination during construction, steel design, detailing, manufacturing and assembly features simultaneously.

•Automatic numerical analysis can be calculated much more easily. Hence, the estimation process can be started at the early design stage.

•Enhance co-operation with key team members, contractors and consultants.

•Team members gain new team roles and skills [3, 5].

2.3. Supporting the Sustainability of Building Information Modeling (BIM) – Green BIM

Sustainable building designs require conscious technology as well as high level collaboration among stakeholders. Sustainable design is provided with the use of BIM as a technology and IPD as a delivery method. The key point in sustainable building designs is to minimize the disturbance to the environment and at the same time contribute to the development of local, regional and global ecosystems. The main issues addressed in sustainable buildings are energy efficiency, efficient use of materials, water saving and healthy interior quality. Effective design parameters in terms of maximum utilization of natural sources, minimum energy consumption and evaluation of important basic issues in sustainable buildings in order to provide climatic, visual and auditory comfort conditions: the location of the structure, the location and the distance of other constructs around it, the orientation and the form of it; physical properties affecting the heat transfer of the building shell, outdoor light level, physical properties of building interior volume, dimensions and structural properties of windows, walls and glass, properties of components constituting artificial lighting system and solar control and natural ventilation systems. It is possible that the main issues mentioned in sustainable structures can be assessed with the conscious analysis tools available in BIM. Thus, providing a sustainable design with predictable fixes of a building that is still in the design stage reduces both waste of time and possible risks. This supports the creation of more comfortable structures [3, 5-6].

2.3.1. Effective Energy Use in Buildings and Carbon Emissions Analysis Performed by Building Information Modeling Tools

A sample pilot study was conducted to measure carbon emissions from buildings by means of BIM tools. First of all, the location information was entered in order to know the climate data. This study is a building project and its location is determined as Gebze/Turkey. Revit Architecture, one of the BIM analysis tools, was used for early phase energy analysis with architectural modeling elements in the building. With the Green Building Studio analysis tool, which is coordinated with Revit Architecture, the carbon emissions were calculated based on the window/wall ratio, the glass thickness of the window and the window shade criteria for the north, south, east and west facades of the project. In line with the calculations made, a 3D virtual prototype of a building project which is still in the design phase has been created and optimum decisions have been taken based on carbon emissions. The exterior of the building designed for a family of 5 is shown in Fig 1 below [7].

Fig 1. The exterior of the building project

In early design phases, energy analysis with BIM tools can support sustainability with the following items.

•Foreseeing the energy consumption of the building to be built
•Building design and system optimization to achieve cost effective and more sustainable solutions
•The best decision on energy conservation measures implemented in the project can be made while still in the design phase
•Achieving LEED credit scores in LEED EA 1 "Optimized Credit Performance" [5]

3. RESULTS AND DISCUSSION

3.1. Findings Related to Carbon Emissions and Energy Modeling

The Energy Use Intensity and Life Cycle Energy Usage/Cost of the building project, which was determined as Gebze, was determined after the energy analysis in Revit Architecture. Fig 2 below shows the climate graph of Gebze province.

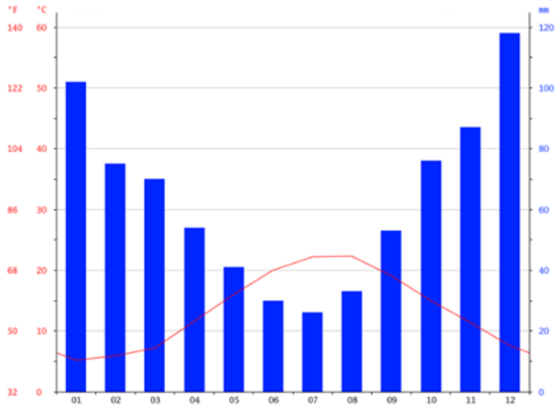

Fig. 2. Climate graph of Gebze

Table 1 below shows the numerical data of the Building Performance Factors performed by the intelligent measurement devices of the pilot study [7].

Table 1. Building performance factors

Location	Gebze/Turkey
Outdoor Temperature	Max:34°C/Min:-4°C
Floor Area	806 m^2
Exterior Wall Area	505 m^2
Average Lighting Power	9.69 w m^{-2}
People	5
Exterior Window Ratio	0.81
Electrical Cost	\$0.14 kWh^{-1}
Fuel Cost	\$1.44 $Therm^{-1}$

Energy analysis is based on Building Performance Factors and then Energy Usage Density and Life Cycle Energy Usage / Cost is calculated according to this information. Table 2 and 3 below shows the numerical information on Energy Use Density and Life Cycle Energy Use / Cost, respectively [7].

Table 2. Energy use intensity (EUI)

Elecricity EUI	181 kWh sm^{-1} yr^{-1}
Fuel EUI	485 MJ sm^{-1} yr^{-1}
Total EUI	1,137 MJ sm^{-1} yr^{-1}

Table 3. Life cycle energy use/cost

Life Cycle Electricty Use	4,321,263 kWh
Life Cycle Fuel Use	11,570,625 MJ
Life Cycle Energy Use	$344,578

*30-year life and 6.1% discount rate for costs

After the energy analysis in Revit Architecture, the energy and cost comparisons of the building project transferred to Green Building Studio were examined. Thanks to these tools, the effects of glass thickness, window wall ratio and window shades on carbon emissions were predicted. The following tables show the optimum results for carbon emissions by analyzing the Green Building Studio for the north, south, west and east fronts, respectively [8].

Table 4. Results of energy analysis and carbon emissions for northern fronts

Glass Thickness	Window Wall Rate	Window Shades	Energy Use Intensity (MJ m^{-2} year^{-1})	Annual Electricity Usage (kWs)	Annual Fuel Usage (MJ)	Annual Electricity Cost ($)	Annual Fuel Cost ($)	Annual Total Energy Cost ($)	Annual Carbon Emissions (mg)
Single Clear	%95	-	1,341.2	151.787	520,003	21,098	7.115	28.214	25.9
Double Clear	%95	-	1,251.5	149,701	456,137	20,808	6,241	27,050	22.7
Double LoE	%95	-	1,211.6	149,398	425,499	20,766	5,822	26,589	21.2
Triple LoE	%95	-	1.137.1	144,208	384,997	20,045	5,268	25,313	19.2
Single Clear	%95	1/3	1.330.0	150,194	516,829	20,877	7,072	27,949	25.8
Double Clear	%95	1/3	1.241.6	148,347	453,162	20,620	6,201	26,821	22.6
Double LoE	%95	1/3	1,200.4	147,463	423,567	20,497	5,796	26,293	21.1
Triple LoE	%95	1/3	1,139.4	144,950	384,138	20,148	5,256	25,404	19.2
Single Clear	%95	2/3	1,325.0	148,997	517,159	20,711	7,076	27,787	25.8
Double Clear	%95	2/3	1,237.9	147,842	452,065	20,550	6,186	26,736	22.5
Double LoE	%95	2/3	,197.9	147,214	422,515	20,463	5,781	26,244	21.1
Triple LoE	%95	2/3	1,138.6	144,744	384,250	20,119	5,258	25,377	19.2
Single Clear	%65	-	1,269.0	149,028	472,493	20,715	6,465	27,180	23.6
Double Clear	%65	-	1,197.6	146,701	424,079	20,391	5,803	26,194	21.1
Double LoE	%65	-	1,165.4	145.806	401,755	20,267	5,497	25,764	20.0
Triple LoE	%65	-	1,118.2	142,717	375,304	19,838	5,135	24,973	18.7
Single Clear	%65	1/3	1,262.6	148,191	470,445	20,599	6,437	27,036	23.5
Double Clear	%65	1/3	1,192.4	145,910	422,798	20,282	5,785	26,067	21.1
Double LoE	%65	1/3	1,159.9	144,831	400,843	20,132	5,485	25,616	20.0
Triple LoE	%65	1/3	1,122.5	143,760	374,997	19,983	5,131	25,114	18.7
Single Clear	%65	2/3	1,259.5	147,556	470,259	20,510	6,435	26,945	23.5
Double Clear	%65	2/3	1,193.6	146,325	422,271	20,339	5,778	26,117	21.1
Double LoE	%65	2/3	1,161.0	145,179	400,447	20,180	5,479	25,659	20.0
Triple LoE	%65	2/3	1,122.8	143,846	374,879	19,995	5,130	25,124	18.7
Single Clear	%30	-	1,169.3	144,133	410,865	20,034	5,622	25,656	20.5
Double Clear	%30	-	1,128.5	142,309	385,006	19,781	5,268	25,049	19.2
Double LoE	%30	-	1,112.8	142,052	373,417	19,745	5,110	24,855	18.6
Triple LoE	%30	-	1,092.9	140,642	362,657	19,549	4,962	24,512	18.1
Single Clear	%30	1/3	1,170.2	144,501	410,227	20,086	5,613	25,699	20.5
Double Clear	%30	1/3	1,131.8	143,080	384,799	19,888	5,265	25,153	19.2
Double LoE	%30	1/3	1,112.8	142,127	373,167	19,756	5,106	24,862	18.6
Triple LoE	%30	1/3	1,094.3	141,018	362,433	19,601	4,959	24,561	18.1
Single Clear	%30	2/3	1,168.9	144,242	410,107	20,050	5,612	25,661	20.5
Double Clear	%30	2/3	1,131.9	143,121	384,751	19,894	5,265	25,158	19.2
Double LoE	%30	2/3	1,112.5	142,059	373,143	19,746	5,106	24,852	18.6
Triple LoE	%30	2/3	1,094.7	141,059	362,568	19,607	4,961	24,568	18.1

Table 5. Results of energy analysis and carbon emissions for southern fronts

Glass Thickness	Window Wall Rate	Window Shades	Energy Use Intensity (MJ m^{-2} $year^{-1}$)	Annual Electricity Usage (kWs)	Annual Fuel Usage (MJ)	Annual Electricity Cost ($)	Annual Fuel Cost ($)	Annual Total Energy Cost ($)	Annual Carbon Emissions (mg)
Single Clear	%95	-	1,479.4	179,281	530,861	24,920	7,264	32,184	26.5
Double Clear	%95	-	1,381.2	173,859	472,289	24,166	6,462	30,629	23.6
Double LoE	%95	-	1,374.3	177,508	453,682	24,674	6,208	30,881	22.6
Triple LoE	%95	-	1,176.2	152,713	385,427	21,227	5,274	26,501	19.2
Single Clear	%95	1/3	1,320.5	156,632	486,104	21,772	6,651	28,423	24.2
Double Clear	%95	1/3	1,241.7	154,199	432,152	21,434	5,913	27,347	21.6
Double LoE	%95	1/3	1,226.7	156,532	411,426	21,758	5,630	27,388	20.5
Triple LoE	%95	1/3	1,113.5	143,840	367,563	19,994	5,029	25,023	18.3
Single Clear	%95	2/3	1,250.9	146,591	466,883	20,376	6,388	26,765	23.3
Double Clear	%95	2/3	1,182.2	145,506	416,174	20,225	5,695	25,920	20.8
Double LoE	%95	2/3	1,159.6	146,937	393,050	20,424	5,378	25,802	19.6
Triple LoE	%95	2/3	1,091.2	139,797	364,381	19,432	4,986	24,418	18.2
Single Clear	%65	-	1,328.4	163,100	469,043	22,671	6,418	29,089	23.4
Double Clear	%65	-	1,250.1	158,422	423,628	22,021	5,797	27,817	21.1
Double LoE	%65	-	1,243.0	160,722	409,702	22,340	5,606	27,946	20.4
Triple LoE	%65	-	1,123.4	145,968	367,773	20,290	5,032	25,322	18.3
Single Clear	%65	1/3	1,237.0	150,236	442,715	20,883	6,058	26,941	22.1
Double Clear	%65	1/3	1,176.1	148,085	402,000	20,584	5,501	26,084	20.0
Double LoE	%65	1/3	1,163.3	149,637	386,238	20,800	5,285	26,085	19.3
Triple LoE	%65	1/3	1,091.7	140,839	360,992	19,577	4,940	24,516	18.0
Single Clear	%65	2/3	1,193.9	143,892	431,242	20,001	5,901	25,902	21.5
Double Clear	%65	2/3	1,141.1	142,785	393,252	19,847	5,381	25,228	19.6
Double LoE	%65	2/3	1,125.1	143,854	376,752	19,996	5,155	25,151	18.8
Triple LoE	%65	2/3	1,079.1	138,299	360,120	19,224	4,928	24,151	18.0
Single Clear	%30	-	1,157.2	146,133	394,000	20,312	5,391	25,704	19.6
Double Clear	%30	-	1,119.4	143,863	372,119	19,997	5,092	25,089	18.6
Double LoE	%30	-	1,113.5	144,770	364,200	20,123	4,983	25,106	18.2
Triple LoE	%30	-	1,074.3	138,858	354,372	19,301	4,848	24,149	17.7
Single Clear	%30	1/3	1,125.4	141,051	387,065	19,606	5,296	24,902	19.3
Double Clear	%30	1/3	1,098.1	139,952	369,268	19,453	5,053	24,506	18.4
Double LoE	%30	1/3	1,090.7	140,608	361,044	19,544	4,940	24,485	18.0
Triple LoE	%30	1/3	1,067.1	136,818	355,893	19,018	4,870	23,887	17.7
Single Clear	%30	2/3	1,115.3	138,927	386,682	19,311	5,291	24,602	19.3
Double Clear	%30	2/3	1,090.1	138,159	369,375	19,204	5,054	24,258	18.4
Double LoE	%30	2/3	1,081.8	138,676	360,910	19,276	4,938	24,214	18.0
Triple LoE	%30	2/3	1,064.9	135,944	357,347	18,896	4,890	23,786	17.8

Table 6. Results of energy analysis and carbon emissions for western fronts

Glass Thickness	Window Wall Rate	Window Shades	Energy Use Intensity (MJ m^{-2} $year^{-1}$)	Annual Electricity Usage (kWs)	Annual Fuel Usage (MJ)	Annual Electricity Cost ($)	Annual Fuel Cost ($)	Annual Total Energy Cost ($)	Annual Carbon Emissions (mg)
Single Clear	%95	-	1,544.1	184,723	562,740	25,676	7,700	33,377	28.1
Double Clear	%95	-	1,486.6	184,140	519,084	25,596	7,103	32,698	25.9
Double LoE	%95	-	1,489.1	188,526	505,305	26,205	6,914	33,119	25.2
Triple LoE	%95	-	1,262.5	162,562	418,636	22,596	5,728	28,324	20.97
Single Clear	%95	1/3	1,459.7	173,948	534,413	24,179	7,313	31,491	26.7
Double Clear	%95	1/3	1,405.0	173,481	492,597	24,114	6,740	30,854	24.6
Double LoE	%95	1/3	1,399.7	176,701	476,789	24,561	6,524	31,085	23.8
Triple LoE	%95	1/3	1,206.4	154,166	404,204	21,429	5,531	26,960	20.2
Single Clear	%95	2/3	1,398.1	165,393	516,261	22,990	7,064	30,054	25.7
Double Clear	%95	2/3	1,343.8	165,141	473,990	22,955	6,486	29,440	23.6
Double LoE	%95	2/3	1,338.2	168,286	458,196	23,392	6,270	29,661	22.9
Triple LoE	%95	2/3	1,170.4	149,199	393,522	20,739	5,385	26,123	19.6
Single Clear	%65	-	1,414.1	173,455	499,942	24,110	6,841	30,951	24.9
Double Clear	%65	-	1,354.7	170,848	462,115	23,748	6,323	30,071	23.0
Double LoE	%65	-	1,350.9	173,200	450,590	24,075	6,166	30,240	22.5
Triple LoE	%65	-	1,185.7	152,558	393,589	21,206	5,386	26,591	19.6
Single Clear	%65	1/3	1,350.3	164,713	480,657	22,895	6,577	29,472	24.0
Double Clear	%65	1/3	1,295.4	162,565	444,751	22,597	6,086	28,682	22.2
Double LoE	%65	1/3	1,287.7	164,357	432,163	22,846	5,913	28,759	21.6
Triple LoE	%65	1/3	1,153.2	148,074	383,832	20,582	5,252	25,834	19.1
Single Clear	%65	2/3	1,296.6	156,647	467,000	21,774	6,390	28,164	23.3
Double Clear	%65	2/3	1,244.8	154,972	431,876	21,541	5,909	27,451	21.5
Double LoE	%65	2/3	1,236.5	156,694	419,096	21,780	5,735	27,515	20.9
Triple LoE	%65	2/3	1,130.6	145,039	376,857	20,10	5,157	25,317	18.8
Single Clear	%30	-	1,212.1	151,708	417,592	21,087	5,714	26,801	20.8
Double Clear	%30	-	1,173.9	149,420	395,470	20,769	5,411	26,181	19.7
Double LoE	%30	-	1,169.7	150,503	388,272	20,920	5,313	26,233	19.4
Triple LoE	%30	-	1,106.5	142,922	365,304	19,866	4,999	24,865	18.2
Single Clear	%30	1/3	1,184.1	147,878	409,143	20,555	5,598	26,154	20.4
Double Clear	%30	1/3	1,150.5	146,212	388,453	20,323	5,315	25,639	19.4
Double LoE	%30	1/3	1,144.2	146,962	380,746	20,428	5,210	25,638	19.0
Triple LoE	%30	1/3	1,094.9	141,242	362,104	19,633	4,955	24,587	18.1
Single Clear	%30	2/3	1,165.8	145,384	403,536	20,208	5,522	25,730	20.1
Double Clear	%30	2/3	1,134.3	144,065	383,307	20,025	5,245	25,270	19.1
Double LoE	%30	2/3	1,127.4	144,625	375,748	20,103	5,141	25,244	18.7
Triple LoE	%30	2/3	1,086.7	139,972	360,174	19,456	4,928	24,385	18.0

Table 7. Results of energy analysis and carbon emissions for eastern fronts

Glass Thickness	Window Wall Rate	Window Shades	Energy Use Intensity (MJ m^{-2} year^{-1})	Annual Electricity Usage (kWs)	Annual Fuel Usage (MJ)	Annual Electricity Cost ($)	Annual Fuel Cost ($)	Annual Total Energy Cost ($)	Annual Carbon Emissions (mg)
Single Clear	%95	-	1,446.5	169,200	541,056	23,519	7,403	30,922	27.0
Double Clear	%95	-	1,372.0	168,604	483,899	23,436	6,621	30,057	24.1
Double LoE	%95	-	1,375.0	173,330	469,301	24,093	6,422	30,515	23.4
Triple LoE	%95	-	1,154.6	148,679	382,813	20,666	5,238	25,905	19.1
Single Clear	%95	1/3	1,328.5	153,648	503,158	21,357	6,885	28,242	25.1
Double Clear	%95	1/3	1,258.0	153,102	449,074	21,281	6,145	27,426	22.4
Double LoE	%95	1/3	1,251.6	156,093	433,216	21,697	5,928	27,625	21.6
Triple LoE	%95	1/3	1,098.9	141,404	364,724	19,655	4,991	24,646	18.2
Single Clear	%95	2/3	1,257.0	144,942	477,687	20,147	6,536	26,683	23.8
Double Clear	%95	2/3	1,190.1	144,568	425,850	20,095	5,827	25,922	21.2
Double LoE	%95	2/3	1,177.7	146,637	408,524	20,383	5,590	25,972	20.4
Triple LoE	%95	2/3	1,062.7	136,404	353,916	18,960	4,843	23,803	17.7
Single Clear	%65	-	1,288.1	154,800	466,905	21,517	6,389	27,906	23.3
Double Clear	%65	-	1,218.7	152,127	421,380	21,146	5,766	26,912	21.0
Double LoE	%65	-	1,214.4	154,440	409,590	21,467	5,605	27,072	20.4
Triple LoE	%65	-	1,084.8	141,181	354,257	19,624	4,847	24,471	17.7
Single Clear	%65	1/3	1,218.9	146,549	441,56216.1	20,370	6,042	26,412	22.0
Double Clear	%65	1/3	1,155.7	144,524	398,630	20,089	5,455	25,543	19.9
Double LoE	%65	1/3	1,146.9	146,215	385,514	20,324	5,275	25,599	19.2
Triple LoE	%65	1/3	1,051.0	136,602	343,898	18,988	4,706	23,693	17.2
Single Clear	%65	2/3	1,170.1	140,134	425,915	19,479	5,828	25,307	21.2
Double Clear	%65	2/3	1,113.4	138,896	385,219	19,307	5,271	24,578	19.2
Double LoE	%65	2/3	1,101.8	140,206	371,294	19,489	5,081	24,569	18.5
Triple LoE	%65	2/3	1,029.7	133,491	338,143	18,555	4,627	23,182	16.9
Single Clear	%30	-	1,104.4	139,604	375,578	19,405	5,139	24,544	18.7
Double Clear	%30	-	1,066.7	137,846	351,911	19,161	4,185	23,976	17.6
Double LoE	%30	-	1,061.8	138,703	344,908	19,280	4,719	23,999	17.2
Triple LoE	%30	-	1,013.7	133,152	326,631	18,508	4,469	22,977	16.3
Single Clear	%30	1/3	1,076.9	135,805	367,348	18,877	5,027	23,903	18.3
Double Clear	%30	1/3	1,043.5	134,596	345,182	18,709	4,723	23,432	17.2
Double LoE	%30	1/3	1,036.6	135,160	337,637	18,787	4,620	23,407	16.8
Triple LoE	%30	1/3	1,005.4	131,786	325,017	18,318	4,447	22,766	16.2
Single Clear	%30	2/3	1,062.3	133,618	363,636	18,573	4,976	23,549	18.1
Double Clear	%30	2/3	1,032.4	132,843	342,671	18,465	4,689	23,154	17.1
Double LoE	%30	2/3	1,024.1	133,206	334,764	18,516	4,581	23,096	16.7
Triple LoE	%30	2/3	999.8	130,780	324,151	18,178	4,435	22,614	16.2

As a result of the data obtained from the above tables, the effects of the energy analysis on the carbon emissions of windows and walls are explained by 3 items.

1. As window thickness increases, carbon emissions decrease
2. As the window / wall ratio decreases, carbon emissions decrease
3. As the window canopy ratio increases, carbon emissions are decreasing [8]

4. CONCLUSIONS

The hypothesis advocated by the study; sustainable architectures, which need to be supported more for the sustainable environment, are subjected to an integrated work with building information modeling, and the analyzes made by means of tools within the structure can be seen, changed and obtained at the earliest design stage. This ensures that resources are preserved, less contamination is created, savings efficiency is increased and time loss and potential risks are reduced. Within the scope of the study, the effects of greenhouse gases from buildings which are one of the biggest reasons for climate change were pointed out. The effects of window glass thickness, window wall ratio and window shades rates on carbon emissions was supported by numerical data. Furthermore, the study encouraged the use of various technological tools to reduce greenhouse gases from buildings.

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BOOK REVIEW

Finnish water services: Experiences in global perspective

by Tapio S. Katko, Finnish Water Utilities Association, 2016, 288 pp.
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Great Turkish poet Necip Fazil Kisakurek summarized the importance of water in a unique way:

"Kâinatta ne varsa suda yaşadı önce;
Üstümüzden su geçer doğunca ve ölünce"

"Whatever in the universe lived in water first;
Water passes over us when we born and when we die"

In technical sense, water is essential for living beings (human and animals) to pursue their lives, for irrigation of agricultural areas, and for hydroelectric power. However, the sudden and heavy rainfall that we face as a result of global warming in recent years, is transforming life-giving water into life-taking water.

The increase in population, consumer habits and accordingly the consumption, natural resources, especially water resources, are rapidly decreasing and a significant part of water is being polluted before being used. Unfortunately, in many parts of the world, especially in Africa, people are unable to reach adequate and healthy water, and many people die related to the lack of adequate clean water.

Preservation of water resources, treatment of drinking water with appropriate methods, and the treatment of the consumed water before discharging to the receiving environment requires public awareness and certain technologies.

Water is essential for our lives as well as the air we breathe. Although most of the earth is covered with water, it is not always ready for human consumption. About 2.5 billion people live with insufficient clean water and 750 million people do not have access to safe water.

Non-clean water or inadequate water sources can cause people and animals to become ill for years and even lead to the end of their lives. Furthermore, natural water cycle, starting from rain falling from the sky to water consumption by the end user requires a long time. Water service industries include public or private institutions that supply, transmit, process and refine water.

The book, "Finnish Water Services: The Global Perspective" written by Tapio S. Katko is 288 pages altogether. The book summarizes the history and development of water services and water regulations in Finland and in other countries. The book is well organized and divided into four parts including 19 chapters discussing technological, environmental, governance and social issues; a poetic epilogue and references. The expressed data and examples are very rich and interesting.

The first part, Water Problems, Solutions and Technology Development, consists of 9 chapters. These chapters expressed a detailed confirmation to the reader about the importance of water services in Finland and trends in international water policy from 1960s to 2020s. The discussed sections are about important milestones in the development of water services, expert networks, selection of water resources, efficiency of water usage, development of water treatment, status of old storage and distribution systems, and environmental protection and pollution control. Additionally, the various environmental, sociological and technological challenges that Finland and other countries need to provide their basic services successfully are discussed in this section. Part 1 constitutes the majority of the book (40%).

Operational Environment and Economics of Water Services constitutes the second part with two chapters. In this section, alternatives for the improvement of water services for both customers and citizens are described. Recommendations for

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effective water management to different water providers and their assistants are also given. The author offers practical advice to further increase the needs and wishes of the customers.

The third part "Institutional Development and Governance" consists of five chapters and discussed policies and laws, development of competencies, professional and voluntary cooperation, public and private sector cooperation, and changing international water arena. The development of competencies in Water Services chapter is examined in terms of education, research and development. There are several examples for water managers in this part.

The fourth part, "Societal Importance and Futures", focuses on socially-learned and future-oriented courses. Katko compares water service applications in different countries and expressed the lessons learned. The challenges of water and sanitation until 2030 are also examined by the author. In addition, it presents different reactions/opinions of seven international experts and academicians from developed and developing countries (Latin America, India, Japan, Kenya, Netherlands, Ukraine, USA-Colorado). Katko synthesizes the data from other departments by reviewing urban water resources in terms of political, economic, social, technological, environmental and legal aspects.

At the end of this part, a poetic epilogue called "Keep Services Rolling" is included. This creative epilogue contains the main points in the book. This section shows to what extent the author's interest in water services.

The handling of water issues in Finland may not be applicable for many other countries. Population is small (5.4 million) and surface area is large (304000 km2). Most importantly, Finland is very rich in ground and surface water sources (56000 lakes over 1 ha and 30 rivers over 100 km). But it is important to benefit from the solutions developed for Finland. The Finns share their experiences in water services and apply their knowledge/experience in different countries (Egypt, Ethiopia, Kenya, Nepal, Sri Lanka, Tanzania, Vietnam). In addition, Katko generalizes the local knowledge and makes it possible to attract the attention of readers from outside the Nordic countries. For this reason, Finnish Water Service book, written by Professor Tapio S. Katko, who has devoted his life to water issues; is attractive for anyone wishing to increase their knowledge about water services. Katko has not only presented the fascinating and legible history of the Water Services industry in Finland but also addressed many water issues facing other countries, including Finland. Water security, which is one of the important geopolitical issues of the 21st century, hence the water services sector will be important for everyone. In this respect, the introduction of this book with larger nations should be welcome.

This colorful volume written by Katko is very well illustrated with various photographs. Thus, reading the book becomes more enjoyable.

It is concluded that the future of water services is as dynamic as the past and that new challenges are constantly emerging. The industry is moving slowly as the planning horizon of water assets can exceed a century. This book, which addresses the past, present and future of Finnish Water Services, is a guidebook that offers multidisciplinary perspective that emphasizes a nation's expertise in water management.