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LANDFILL POLLUTION ASSESSMENT IN RESIDENTIAL URBAN SPACES IN LEBANON

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Abstract

Landfill site is a significant and risky part at the same time in the city. In planning an urban city, the pollution caused by landfill damages the surrounded areas, especially the residential zones, if it does not follow the sanitary landfill rules. The pollution from landfills threat the environment and, consequently, human health and wellbeing, so it is essential to maintain a safe and healthy environment in selecting the landfill site. From this point of view, the research aims to create a method to evaluate the affected residential zones by the nearest landfills to protect people from pollution's negative impacts. The research objective is to determine the most impacted residential areas of pollution caused by landfills by combining multiple criteria for studying the selected landfill locations that help determine the degree of contamination (high risk to no risk) in each residential area. The study is conducted in four different locations in Lebanon; three coastal areas and one inward area, to evaluate the differentiation in the meteorological conditions and how they increase the landfill pollution that affect the close inhabitants' zones. By combining the buffer zone criteria and weather factors (temperature, humidity, and wind), the data collected is analysed using the overlay analysis method to determine the most affected residential area by landfill. The assessment in this study found that the pollution degree differs in the residential zones according to the criteria applied, and the weather factors play a significant role in increasing the pollution. By adopting this study's assessment, the urban design decisions for a new residential zone could benefit from this research's method to provide a healthy area.

Keywords

Landfill pollution, residential area, pollution assessment

1. INTRODUCTION

Planning urban cities should maintain the occupants' comfort and health, especially in the residential zones, to provide a healthy environment for the inhabitants. In planning and designing architectural, urban areas, all the city's major parts must be replaced not negatively to affect the other parts of the city. From this point of view, the residential areas are sensitive parts of the urban metropolis that provide relaxation and wellbeing for the people and should be isolated from the city's harmful parts. The landfill is the most dangerous part of the town as this zone pollutes the surrounded area, so it is vital to locate the dumps remote from human activities and places to protect them from a significant pollution source.

Landfill biological reactions should be improved to decrease the harmful effect of landfills. Future planning of landfill should be achieved considering inhabitants' locations, water surfaces and eco-sensitive territories (Singh & Farswan, 2019).

Research Background

The Landfill location selection is a significant issue in rural and urban territories because of the risky effects of the landfill on the biology, natural well-ing, and economy of the zone (Kamel & Hasan, 2018). Municipal solid waste (MSW) organization in transition and developing nations contains more significant portions of natural waste and less benefit from the energy generation than developed nations (AZZI, 2017). Regardless of the severe impacts produced through landfill, there are no past examinations on wellbeing and ecological effects on the inhabitants living near the landfill.

According to the investigation, the members who lived near the landfill spot showed definite air quality pollution from awful smells connected to the landfill location (Hidayati, Utomo, & Kusnoputranto, 2020). It is essential to provide valuable knowledge for odour's management from the Municipal Solid Waste (MSW) management facility in a developing country (Tran, Murayama, Enomoto, & Nishikizawa, 2020). The landfill can be appropriate in the developing city as it is considered the least expensive and clear strategy (Islam, Kashem, & Morshed, 2020). The critical features of developed new towns are a high density of population. The landfill is one of the eldest waste dumping techniques that offer a simple and low-cost solution (Singh & Farswan, 2019). The authority in developing countries is concerned with adapting the growing issues identified with eliminating trash (Mainul Sk, Ali, & Ahmad, 2020). Globally, developments referred to the importance of the waste management sector's greening (Ahlbäck, 2011).

Depending on the mentioned previously and as Lebanon is considered a developing country, the landfills in Lebanon have the major distribution throughout the country. The waste disposal is distributed as follow: Landfilled: 48%, Composted: 15%, Dumped: 29%, Recycled: 8 % (SweepNet, 2014), (Jadam, El-Jisr, & Stephan, State and Trends of the Lebanese Environment, 2011), and (Abbas, Chaaban, Al-Rabaa, & Shaar, 2017) this study problem focuses on the landfilling issue and its contamination dilemma.

The report (Board, 2017) clarifies that the landfill site should be away from the inhabitant area as it is a source of water, air, noise, smell, and land pollution. Living close to landfill increases the air quality in the area, including the bad smell and affecting the quality of life (Hidayati, Utomo, & Kusnoputranto, 2020). People dwelling close to a landfill face numerous medical conditions, respiratory and general wellbeing weaknesses like diseases, get into depression and some of the time they could have loss of memory (Singh & Farswan, 2019). The waste management crisis was started in Lebanon in July 2015, approaching unfortunate outcomes at the wellbeing and climate levels. Later, causing of the current issue incorporate political preference and the nonattendance of long haul arranging, even though its results include unapproved landfills and burning locales close to inhabited regions (Hilal, Fadlallah, Jamal, & El-Jardali, 2015).

From this point of view, living close to a landfill site causes severe problems to the inhabitants from air, water, and soil contamination and the impact on people' health; the study will emphasize the pollution produced by landfills located near residential zones.

This research problem is focused on the inappropriate locations of the landfills in the cities near residential areas that causes contamination disturbs these places, and relatively harm the inhabitants' health and wellbeing.

The research aims to create a method to evaluate the affected residential zones by the landfills located nearby to protect people from pollution's negative impacts.

The research objective is to determine the most impacted residential areas of pollution caused by landfills by combining multiple criteria in studying the selected landfill locations to find out the degree of contamination in each residential area.

The research question is: What is the degree of pollution in each residential zone locates nearby a landfill site?

The methodology applied in this research is a first step in defining the types of contamination produced by landfills and their effects on the residential spaces. Second, collecting data about the landfill criteria that should be maintained in deciding the landfill site. The third step is selecting different landfill locations near residential areas, then applying the previously collected standards using the overlay analysis method to assess the established residential neighborhoods and finding out the most polluted place because of its existence close to the landfill.

The case study in this research includes four different landfill locations in Lebanon situated near residential zones to assess the pollution in these areas and determine the most affected one.

To clarify the importance of this problem, the next part of the literature review will present the types of pollution composed from the landfill site as a contamination source. Then, the criteria and sub-criteria of establishing a landfill will be gathered from different resources and gathered to achieve the appropriate criteria that should be considered in selecting the landfill site to prevent the negative pollution effects on the residential zone in specific to make the assessment in this study regarding the landfill criteria that are related to the urban inhabitants' areas.

2. POLLUTION FORMS FROM LANDFILL

Landfill destruction locations are significant origins of contamination that result in ecotoxicological impacts and have long haul persistent effects. It influences all the degrees of natural life directly from atomic level Geodiversity and influences nature up to the biological system level. They influence the entire biological system, both basically and practically. When the landfill leachate goes into surface water or groundwater, it is useless for drinking and other local functions. The leachates arrive in a natural food chain over the long term. Foreign substances from landfills lead to harmfulness; for example, heavy metals like arsenic, mercury, PVC, cadmium, acids, solvents are discovered in landfills. Methane is additionally a combustible gas and represents a steady risk. Carbon dioxide is moreover delivered alongside methane. Aside from methane and carbon dioxide, which establishes 90-98% of landfill gas, the remaining gases are oxygen, nitrogen, hydrogen, sulfides, and different gases.

Smell is a real issue, particularly in the summer. (Singh & Farswan, 2019). Waste management is a significant ecological concern that it is necessary to save the properties and avoid contamination of the climate (Ahmad & Ahamad, 2020). Landfill is the best approach to oversee homegrown and industrial wastes in various countries. If landfill is not operated appropriately, this could lead to natural debasement by delivering different impurities, such as groundwater pollutions and scent releases. Several harmful matters are brought about via landfills like Toxins, Leachate, and greenhouse gasses. Damaging elements are originated from waste like electronic machines that contain dangerous elements (mercury, arsenic, PVC); Leachate is exceptionally harmful that can pollute the land and groundwater. Also, greenhouse gasses eliminate the oxygen and makes it separate in an anaerobic manner (Hidayati, Utomo, & Kusnoputranto, 2020). The landfill could produce soil, air, and water contamination, which might cause general wellbeing risks (Islam, Kashem, & Morshed, 2020).

According to the previously mentioned studies, landfill pollution has several aspects such as: Leachate, gases emissions, groundwater pollutions, scent releases and toxic materials. All these pollutant elements cause water, air, and soil contamination and affect human and nature safety.

3. SELECTING LANDFILL SITE CRITERIA

This part includes a detailed study about the criteria that should be maintained in selecting a landfill location. The upcoming study contains several previous researches that explain the applicated criteria and sub-criteria for establishing a landfill site.

The criteria maintained to select a landfill site includes several factors: environmental, social, and economic factors. The criteria that were studied to determine an environmentally sensitive area for landfill spot are as follow:

1. Soil index: this criterion contains two sub-criteria: slope and drainage.
2. Geology index: this criterion includes two sub-criteria: transmissivity and fault lines.
3. Land use cover index: this criterion comprises six sub-criteria: urban areas, industrial areas, historical sites, natural reserve, roads, and airport.

Sustainable development index: this criterion includes three sub-criteria: snow area, power lines, and coastline. (Kamel & Hasan, 2018)

The importance of choosing appropriate landfill locations should incorporate the physical qualities, ecological effect, social and economic acknowledgement for the manageability network life. This examination presented seventeen universally embraced spatial criteria sorted below the physical, environmental, and socio-economic qualities.

1. The environmental criteria: contains five sub-criteria: surface water bodies, sensitive areas, aquifer potential (groundwater), rainfall intensity (climate), flooding area.
2. The physical criteria: contains eight sub-criteria: road access, soil permeability, haul distance, wind potential, slope, geological fault properties, airport location, bedrock/ lithology.
3. The socio-economic criteria: contains four sub-criteria: residential area, urban area, land use, utilities.

(Ahmad & Ahamad, 2020)

Landfill site selection in request to choose a suitable location for a landfill, numerous criteria are to be thought of:

1. Neighbourhood (distance from residential zone, from airports, and streams and water bodies).
2. Topographical and hydrogeological conditions in the area.
3. Seismic conditions in the region.
4. Presence of groundwater and flow (and future) usage.
5. Danger of flooding, collapsing and avalanches.
6. Transport separates and existing foundation (access streets).
7. Entrance to transitional and last cover material.
8. Geography of location.

(Munawar & Fellner, 2013)

To analyze and assess sanitary waste management landfill spots, the criteria are distributed as follow:
1. Topographical and hydrological rules: quality of landscape, vulnerability, level's depth, stream container size.
2. Ecological measures: significance and distance from peaceful environments, existing greenery in the territory, visual state of the zone.
3. land-arranging standards: distance from residential areas, street or railroad, zone miniature atmosphere components.
4. General and operational criteria: presence of solid winds, climatic circumstances, land morphology of the location, and size.
5. Fiscal cost measures: simplicity of structure, accessibility of networks, technical simplicity and size of the requested foundation, and land value.
(Sfakianaki & Kasis , 2020)

According to standards and regulations, the criteria used to select a landfill site are mentioned as follow:
1. Economic criteria: that includes five sub-criteria: elevation, slope, distance from main roads, distance from railway, and land value.
2. Geology criteria: that provides for two sub-criteria: soil formations and groundwater depth.
3. Eco-sociology criteria: that includes five sub-criteria: distance from settlements, distance from protected areas, land use, distance from airfields, and distance from secondary collection points.
4. Hydrology or climate criteria: aspect (wind direction), distance from river and canal, and distance from surface water body.

(Islam, Kashem, & Morshed, 2020)

The previous studies show the applicable criteria and sub-criteria in selecting a landfill site. As this research concerns about studying the negative impact of pollution from the landfill site as a source of pollution that threatens the people's health in the residential areas, the focus will be on the criteria that maintain the distance between the landfill location and the nearest inhabited zone, in addition to the climatic criteria that consider some meteorological conditions in specific seasons increase the pollution in the landfill and consequently increase the negative impact on the surrounded area.

As a summary based on the previously mentioned criteria, the applicable criteria in this research includes:

1. The socio-economic criteria: distance from the residential area; this distance is mentioned in this study as the buffer zone. This criterion will be applicable to find out the distance between each selected landfill site in this study and the nearest residential area.
2. The climatic criteria: includes the study of wind speed and direction, temperature, humidity, and rain. This criterion will be applicable to determine how the differentiation in the metrological conditions could impact the residential area by the landfill's pollution.

The applicable criteria in this study that will be used to make the assessment in the selected areas are as follow:

3.1. Determine Buffer Zone

Selecting a location for a landfill is subjected to strict criteria that should be maintained. The reports cited in (Environment, 2016) and (Board, 2017) are two important reports that provide the details of the criteria to select a landfill site. As each landfill should include a core activity area, 20m for utility area, then 30m of a green belt, and by combining these two areas, it will formulate the buffer zone of (50m) around the landfill's core area.

Landfill location near confined and sensitive areas is carefully restricted because of its diverse issues encompassing the urban environment. (Mainul Sk, Ali, & Ahmad, 2020).

Previous studies determine the buffer zone of the residential area; this buffer zone differs from the buffer zone of the landfill's core, as the distance between the landfill boundary and the boundary of the residential site is also considered a buffer zone that should be maintained. A distance between (300-500m) and the buffer zone between the residential area and nearest landfill is at least two kilometers (Sfakianaki & Kasis , 2020) (Hidayati, Utomo, & Kusnoputranto, 2020). However, other studies determine the distance between the landfill and the nearest residential area to be at least five kilometers. (Oxford, 2016) (Tran, Murayama, Enomoto, & Nishikizawa, 2020) (Kamel & Hasan, 2018). The distinguishing proof and determination method of the landfill location in Malaysia are presented by the separate state governments, as the land is classified as a state issue. Arrangement of enough buffer zone between the planned landfill destinations and residential zones is of vital significance. Under the main criteria (socio-economic) of selecting a landfill site, the sub-criteria of (residential area) that contradicted landfill locations to be arranged close residential zones in proposed standard limits of (1000 m) (Ahmad & Ahamad, 2020). The minimum buffer zone criterion between residential areas and the landfill site (500m) (Munawar & Fellner, 2013). Following the outcomes from a previous examination demonstrates that 78 percent of members who lived near the landfill location (100-500 meters) showed significant pollution of air quality clear from terrible scents connected to the landfill spot (Hidayati, Utomo, & Kusnoputranto, 2020). Based on the Greek regulation of selecting a landfill location, it is mentioned that this site cannot be located nearer than (500 m) from a residential zone. In contrast, a study that was conducted for landfill locations in the UK presented that congenital malformations are probable for individuals living in an area nearer than (2km) from the sites, according to (Sfakianaki & Kasis , 2020) according to (Jarup et al., 2002). A suggested buffer zone in the sub-criteria distance from settlements to be at least (2km) to reduce the pollution impact (Islam, Kashem, & Morshed, 2020).

The arrangement of a sufficient buffer zone between the planned landfill destinations and local locations is of principal significance (Ahmad & Ahamad, 2020). The constraint of siting a landfill close to residential areas is an important matter that should be considered.

According to the previously mentioned studies, the criteria considered to select a landfill site are numerous and divided into sub-criteria. As this study's primary purpose is to determine the pollution caused by landfill and affect the residential zones, the focus will be on the criteria and sub-criteria related to the subject. In this case, the criteria that maintain the distance between the residential zones and the landfill site will be considered in the assessment and the climatic conditions criteria that affect the contamination dispersion.

3.2. Meteorology Conditions

Several weather circumstances increase the quality of odours, whereas others will encourage smell dispersal away from landfill destinations, and there is no hope at solid waste facilities to change the atmosphere or microclimate. Accordingly, solid waste managers must concentrate on working their facilities to diminish any expected effect on close neighborhoods. In this manner, it is essential to gather site-clear information on key meteorological conditions, for example, temperature, wind speed, wind direction, humidity, and other climatic information continuously. According to meteorological conditions, working solid waste facilities can help recognize what climate conditions ruled when a smell protest was recorded. Observing meteorological conditions, certain intense waste activities could be retained and planned for more good climate conditions (Vidovic, 2017). Solid waste quantity, methane, is produced just as meteorological parameters, such as humidity, temperature, and wind speed (Abu Qdais & Shatnawi, 2019).

The environmental criteria contain a sub-criterion of the climate condition of the rainfall intensity that should be defined to avoid erosion and drainage impacts; the proposed standard limits are low intensity (1-10 mm\h). As well, the physical criteria contain a sub-criterion of the wind potential that opposed landfill locations to be unprotected from wind to monitor dust and waste and avoid damages to the landfill substructures due to strong wind, the proposed standard limits for this criterion according to the national solid waste management policy is calm to light air (0-1.5 m\s). (Ahmad & Ahamad, 2020). As odour and airborne pollution caused by landfills could be distributed in the surrounded areas and create people complaints, the study of the odour dispersion pollution considers the meteorological conditions including temperature, wind direction, rainfall, and humidity beside the factor of the distance between the landfill location and the studied area (Tran, Murayama, Enomoto, & Nishikizawa, 2020). The hydrology or climate criteria in selecting landfill site contains a sub-criterion of aspects that presents the role of wind direction that blows toward urban and settlements areas; for this reason, the wind direction study should be investigated for its role in affecting residential areas by odour and dust (Islam, Kashem, & Morshed, 2020). As the environmental criteria includes the wind speed and direction is a significant factor to be considered due to the role in affecting the close areas by odour and dust pollution (Board, 2017). The assessment done in Lebanon for the sanitary landfill of Naameh the evaluation considered the health impacts of this landfill and was done considering the wind direction in the selected case study (STREG, 2017).

As a result, the study will consider the buffer zone criteria between the landfill site and the nearest residential area and the meteorological conditions that increase the degree of pollution in the area.

4. LANDFILL SITES IN LEBANON

In Lebanon, unlicensed landfills and burning locations have risen near residential areas, adding to the importance of the situation (Hilal, Fadlallah, Jamal, & El-Jardali, 2015). Lebanon ought to receive an effective solid waste management framework, uncontrolled dumping and inappropriate waste dealing with causes a range of issues, for example, polluting water, pulling in insects, and expanding flooding because of blocked channels, so inhabitants close to Naameh landfill site constrained from adding to the oversaturated landfill (Mikhael & Saadeh, 2015).

A guest to Beirut will probably encounter the foul smell of the Bourj Hammoud landfill at any rate once. Occupants living close to the site are presented multiple times the ordinary portion of the rotten compound hydrogen sulfide (Boswall, 2019).

Tripoli landfill suffers from various management problems; this landfill leads to various health and environmental crises (Tadmouri & Seif, 2019) (El-Hoz, 2017).

The landfill in Zahle was built to improve the ecological conditions under which strong waste was being arranged by the regions in that locale and remediate the old dump (Jadam, Solid Waste, 2010).

The report published by (SweepNet, 2014) clarifies in detail the landfill sites situation in Lebanon. Starting with Naameh landfill, without treatment services, and another location, the current Naameh landfill limit providing Mount Lebanon and Beirut has surpassed its plan limit without any alternative landfill being distinguished. The immediate result was that the agreement with the privately-owned businesses is over and again stretched out without any changes, and the life expectancy of the Naameh landfill site is, as a rule, consistently expanded each time the limit is achieved. In any case, the undertaking usage has been troublesome, and the activity was downsized before shutting toward the finish of 2003. A landfill had been situated and became operational in Zahleh in the Bekaa valley, serving Zahleh and the surrounding towns (SweepNet, 2014).

A report done in 2012 by the University of Balamand identifies the landfill sites and open dumps in Lebanon, particularly the coastal landfills that causes water pollution in addition to the affected surrounded areas. The landfills mentioned in this study are Tripoli landfill as it is mentioned this site affect El-Mina area. Also, Bourj Hammoud landfill is mentioned as a closed landfill (however, the land next to the old one has been operational as a temporary solution later). Beirut landfill is mentioned as a closed landfill. Naameh landfill is mentioned as a significant source of pollution to the surrounded area. Saida landfill was causing severe environmental contamination as emissions leakage (however, this landfill was transformed to sanitary landfill later). Tyre landfill was also causing water contamination and gas releases, odour, and visual pollution, which negatively affected economic activities. Zahle was mentioned in the report as an open dumping; however, later reports have categorized Zahle as a landfill (Nader, Jazi, Abou Dagher, & Indary, 2012).

Recently, the ghost of a new Lebanese trash emergency lingered as heaps of garbage. The overflow of trash bins onto curbsides followed the goliath landfill's conclusion on Beirut's northern coast when arriving at the limit. Lebanon experiences dreary waste management functions, with waste winding up in landfills that produce poisonous gases took in by the nearby inhabitants. Beirut's two seaside landfills, Bourj Hammoud toward the north and Costa Brava toward the south, were developed as a convenient solution for the 2015 trash emergency, when garbage bursting the roads of Beiruthe conclusion of the Naameh dumpsite (Lewis, 2020).

As a summary and according to the paragraph mentioned previously, the current locations of the landfill sites in Lebanon are the landfill site in Tripoli, Bourj Hammoud landfill, Costa Brava landfill, and Zahle landfill. Although the landfill in Tripoli and Bourj Hammoud is mentioned previously as closed landfills, a new additional area contiguous to the old landfill area has been put in operation as a temporary solution and still functional until the present time.

The next part presents all the landfill locations in Lebanon to determine the landfills that are operational at the current time to help define this research’s case study area.

4.1. Tripoli Landfill

Similarly, to other urban communities, Tripoli experiences a lack of appropriate solid waste management. Tripoli landfill is placed alongside the coastline, north to the Tripoli's port and covers a 60,000 m2. It began to get waste in 1980; later, in the year 2000, it was changed over into a semi-controlled dump with the reconciliation of a gas assortment framework and restraint wall. This landfill must be shut down in 2012; however, tragically, it accepts waste till now; it turns into a mountain perilous that can self-destruct whenever causing a natural catastrophe. This situation caused an ecological disaster area in terms of pollution, fires, odours, and vectors. (Halwani, Halwani, Amine, & Kabbara, 2020)

4.2. Bourj Hammoud Landfill

The initiation of Bourj Hammoud seashore landfill began in the Lebanese civil war as an uncontrolled dumpsite; then, it became an official landfill by governmental decision. After a long time, this landfill had exceeded its capacity and become an environmental and social health threat. Finally, the public authority reacted because of well-known pressing factors from the networks close to the landfill, then the Bourj Hammoud landfill shut on July 20, 1997, without restoration. Although, instead of building up a useful and maintainable answer for the waste management issue, the public authority nearly made another landfill (the Naameh landfill). Today, the Bourj Hammoud landfill delivers an expected 120,000 tons of Leachate every year, compared to the Leachate's greater part by three significant seaside dumpsites in Lebanon (Tripoli, Bourj Hammoud and Normandy). (Moughalian, 2019)

4.3. Naameh landfill

The Naameh landfill was set up in October 1997, after the Bourj Hammoud landfill was forcefully closed down. For the absence of an arranged option in contrast to the Bourj Hammoud landfill, the Naameh landfill was set up at the site of a neglected quarry as a crisis arrangement, a dumpsite for squander with no financial and treatment benefit to citizens. Years later, the residents started to complain about health problems caused by the landfill contamination. In 2013, activists from the region began demanding to close the landfill; then, in 2015, the landfill was finally closed. (Moughalian, 2019)

4.4. Costa Brava Landfill

The landfill of Costa Brava is situated to the south of the capital Beirut next to the airport; it is opened in 2016, as an alternative and temporary solution to the Naameh landfill's closure in 2015, after 17 years of operation. A few months later, protest movement had requested to close this landfill due to the pollution caused by the Costa Brava landfill and its closeness from the airport that could threaten flight safety. The landfill still in operation till the present time. (Meraaby, 2019)

4.5. Zahle Landfill

The landfill in Zahle city pollutes the Litani river that passes through Bar Elias village causing water contamination affecting people health and bad odours that fill up the region. In 2017, Bar Elias residents and numerous associations assembled all together to force the government to stop polluting the river, and nothing has been done. (Mouallem, 2019)

4.6. Saida Landfill

The Saida landfill is located on the southern coastline of this seaside city, and it is only 200 meters far from residential and urban zones. This landfill started as a dumpsite in 1975; after that, it received only sustainable materials in 1982. Then in 2009, clinical and chemical can be found in this dump. Ordinary flames would eject from the landfill because of the mid-year heat and the methane produced by the disintegration of waste, taking the vapor inside the city and uncovering the residents to poisonous air. By 2013, development works started to treat the waste and land recovery with the destruction waste. The remainder of the landfill was transformed into a clean landfill. In 2016, a 33,000 m2 park was opened on the recovered land, with plans for its extension over the landfill site in the long-term time once the material under it breaks down. (Maroun, 2019)

In conclusion, the major landfill locations in Lebanon are not considered sanitary landfills despite numerous attempts to rehabilitate these landfills and operate them safely to prevent environmental pollution and their negative effects on people's health. Tripoli landfill is still opened till the present day and considered as a primary source of pollution. Bourj Hammoud landfill is closed, but it still releases Leachate, smell and harmful effects that disturb the inhabitants close to this area. Naameh landfill is closed without rehabilitation and still a contamination source. Costa Brava landfill is still operating till now. Zahle landfill is still in operation till the present time. Saida landfill is turned into a park, so it is not considered as a source of pollution.

To carefully select the case study in this research, the next part includes two interviews that have been conducted to ensure the location of the landfills in Lebanon and still functional till the present time.

Conducting Interviews

Two interviews have been conducted with two professionals to collect data about the landfills in Lebanon and their negative impacts on the environment and on people's health. The first interview was with an engineer in the municipality responsible for improving the laying of the landfills. The second interview was with an environmental engineer who is in charge of monitoring and developing the landfills' current situation in Lebanon. The interview questions were posed depending on the factors that will be analyzed through this study and ensuring the operational landfill sites in Lebanon at the recent time.

The first interview was a telephone interview, and the second interview was face to face interview; the type of both interviews was a semi-structured interview. The first part of both interviews was structured based on three questions, and the second part of the interview was opened for the professionals to give their opinions about the landfills' situation in Lebanon and the proposed solutions to fix the problem of the landfills' location in Lebanon to protect the environment and people's health. The questions of the interview are as follow:

The first question: What is the distance allowed between the landfill location and the nearest residential area?

The second question: What are the most affected weather conditions that increase the pollution caused by landfills?

The third question: What are the significant landfills in Lebanon that negatively influence the people in residential zones?

These questions help to make the assessment in this research and determine the current landfill sites in Lebanon as case studies.

According to the first interview, the answers were only for the first and third questions as follow:

According to regulations and standards in developed countries, the minimum distance between the landfill and the nearest residential area should be (five kilometers). The landfill is a restricted area that no one can come inside unless with municipality permission. In a developed city as Lyon in France, the landfill area is separated from the town and considered a controlled area where only authorized people can get into it.

Asking about the major landfills in Lebanon, the answer referred to the landfills that considered most important in Lebanon; these landfills are in Tripoli city (Tripoli landfill, port area), Burj Hammoud landfill (to the north of Beirut city), Costa Brava landfill (to the south of Beirut city), and the landfill of Zahle city.

As Lebanon suffers from the landfill's location, numerous solutions were proposed to find a better place to locate the landfill in a better area that could maintain a healthy environment and eliminate the disturbance for the inhabitants close to these areas. For example, a solution was proposed to change the Tripoli landfill location as this landfill exceeded its waste capacity, and the risk of the leachate and fire hazard became severe in addition to its site not far than one kilometer from the nearest residential area. The solution of selecting a new site to be a sanitary landfill containing an integrated leachate treatment system and biogas network and the geological nature of the land is more appropriate to the landfill and far from the urban and residential areas. However, this solution was prevented for different reasons, and an alternative resolution has been adopted temporarily. The new solution was to equip three new cells next to the old landfill to be the new temporary landfill, as each cell receives waste for one year. This solution could not be sustained more than the end of 2021, as these cells started receiving waste at the beginning of 2019. However, the inhabitants' complaints about the new landfill odours have been increased, and soon these three cells will be complete, and no sustainable solution has been adapted until the present time.

According to the second interview, the answers for all the three questions were as follow:

The classified territories regulation in Lebanon for the first category includes the factories, plants (including the landfill location) determine the minimum distance between the plants area and the nearest residential area (one kilometer).

Asking about the meteorological conditions that negatively affect the landfill and could increase the pollution in this area. The answer includes discussing the weather factors (rainfall, wind direction, humidity, and temperature). In case the landfill is too close to a residential zone, the rain could negatively impact the groundwater.

The dominant wind direction in Lebanon comes from the west; as most landfills in Lebanon are located on the coastal area (west of Lebanon), the wind from the west will not significantly impact the surrounded area. However, the wind direction in Lebanon varies from the north and east; in this case, the wind affects and increase the odour pollution from the landfills to the nearest residential zones.

The factors of humidity and temperature are considered risky in summer in the highest temperature degrees and humidity levels; in this case, the landfills' pollution increases and affects the surrounded areas.

According to what is mentioned previously, to find out if the pollution is worst in summer or winter. In summer, the high-temperature degrees and humidity levels combine with the wind direction that varies from east, west, and north; in this case, the evaporation in the landfills increases, causing gas emissions odour pollution will be increased. However, in winter, the risk of pollution increases according to rainfall levels, which become risky when causing floods or collapses inside the landfills. The risk of pollution in this case will be on the environment as the odours could not spread as the rain hold the molecules that cause the bad smells to the ground, so the inhabitants near the landfill area will not be disturbed by landfill odour pollution in this case.

The major landfills in Lebanon are situated on the coastal site (Costa Brava landfill, Saida sanitary landfill, Bourj Hammoud landfill, and Tripoli landfill), except the landfill in Zahle and Naameh landfill that are situated in inward area.

Costa Brava landfill will continue to receive waste until the end of the year 2021; after that, this landfill will be stopped in the saturation stage. Bourj Hammoud landfill is already closed, and the waste is transferred to the new Bourj Hammoud landfill next to the old one. As mentioned in the previous interview, the Tripoli landfill is already closed, and the three new cells had started to receive waste, and it is expected to be full by the end of 2021. Zahle landfill started as a sanitary landfill; however, it has reached the saturation stage, and a new landfill began to receive the waste next to the old one. Saida sanitary landfill; previously, Saida city had a landfill on the coastal area; this landfill in the stage of saturation had been closed then later have been transformed into a public garden. The new sanitary landfill in Saida has been equipped with a waste refinery that contains sorting, processing, and energy production. This explains the reason for considering the landfill in Saida city as a sanitary landfill.

Depending on the interviews, the data collected are summarized as follow:

1. The buffer zone between the landfill location and the residential area ranges from one to five kilometers.
2. The meteorological conditions (wind, temperature, humidity, and rainfall) that negatively affect the landfills' pollution to the close residential areas should be considered in the summer.
3. The major landfills in Lebanon that still in operation at the current time are the Tripoli landfill, Bourj Hammoud landfill, Costa Brava landfill, and Zahle landfill.

The major landfills in Lebanon are in Tripoli, Bourj Hammoud, Costa Brava, Naameh, Zahle, and Saida. As the Saida city's landfill is turned into a park, and Naameh landfill was closed, this study focuses on the significant operational landfills (Tripoli landfill, Bourj Hammoud landfill, Costa Brava landfill) Zahle landfill) that are considered as contamination sources.

The appropriate buffer zone's determination will depend on the interviews' data and numerous previous studies.

The study analysis will also benefit from the various weather factors to find out the most affected residential area by the nearest landfill.

5. THE SELECTED CASE STUDY

Depending on the previous paragraph, and for the purpose to make an assessment for the affected residential areas by the landfill pollution considering the criteria of the landfill site distance from residential zone and meteorology conditions that influence the level of landfill pollution, the selected regions of Lebanon include three major coastal landfills located near residential areas, and one landfill located in the inward area. The reason for choosing two different geographical areas is to compare the assessment results to determine how the various weather conditions affect pollution produced from landfills and disturb the nearest inhabitant zones.

The first landfill located on Tripoli seafront (LF1), with an area of 60.000 m2; this landfill affects El-Mina residential area directly.
The second landfill located on Bourj Hammoud seafront (LF2), with an area of 280.000 m2; this landfill affects Bourj Hammoud residential area directly.
The third landfill located on the Costa Brava seafront (LF3), with an area of 150.000 m2; this landfill affects Chouaifat El-Qoubeh residential area directly.
The fourth landfill located in Zahle (LF4), with an area of 150.000 m2; this landfill affects the Haouch El Oumaraa residential area directly.
The study of (Jadam, El-Jisr, & Stephan, State and Trends of the Lebanese Environment, 2011) shows the distribution of the landfills in Lebanon as shown as Fig.1. as this study has been conducted from 2011 before the closing of Naameh and Saida landfill, the selected case studies will include only the operational landfills in Lebanon as explained previously.

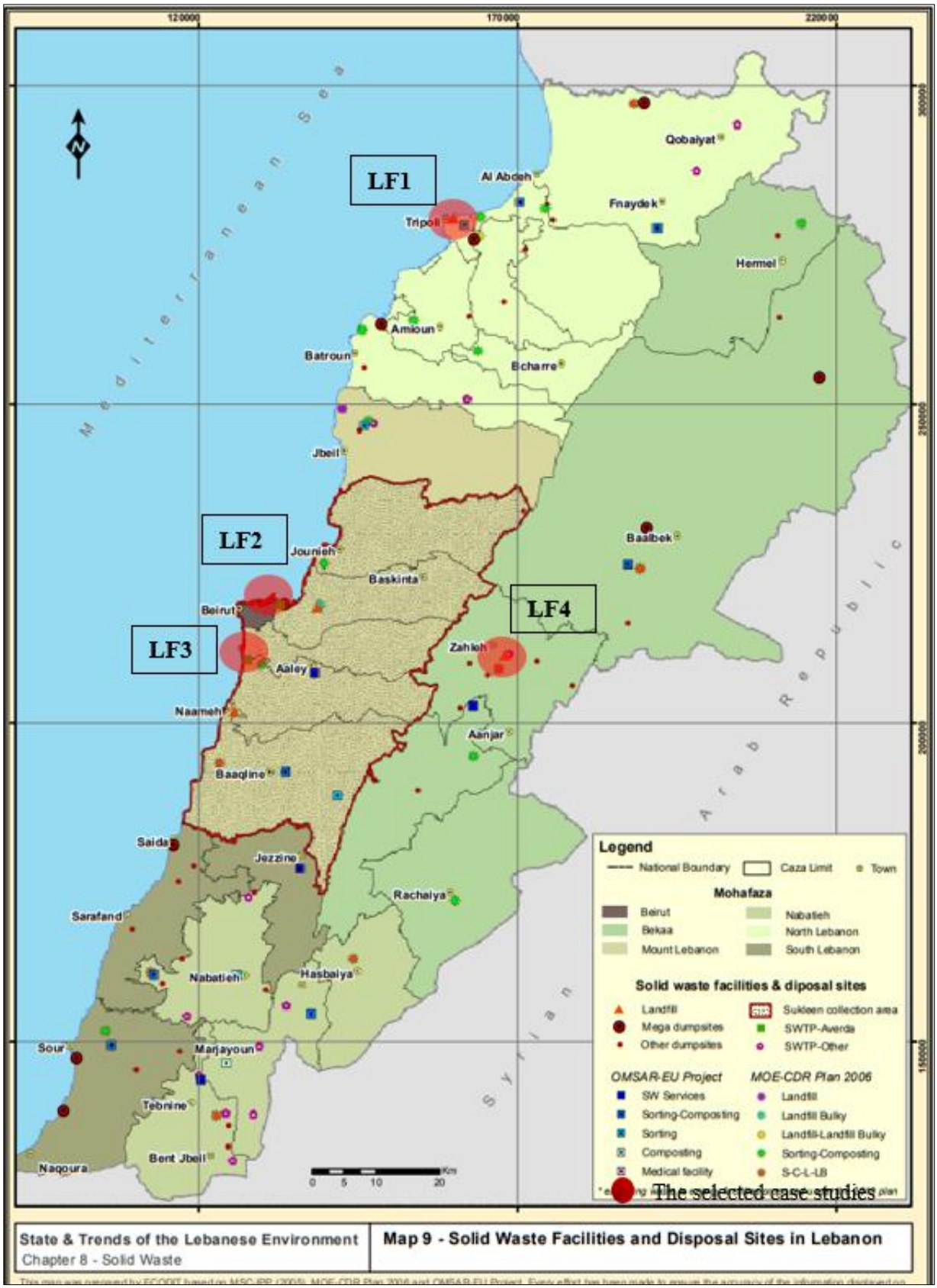


Fig.1: Solid waste facilities and disposal sites in Lebanon. (Jadam, El-Jisr, & Stephan, State and Trends of the Lebanese Environment, 2011)

Tripoli landfill produced an environmental disaster area as far as contamination, fires, vectors, and smell. This landfill situation encouraged private sectors to repair this site and to operate it as a controlled landfill (Halwani, Halwani, Amine, & Kabbara, 2020). As shown as Fig.2

The report of (Alieh, 2016) clarifies that a private company had to participate in a bid to operate the landfill in Bourj Hammoud and remove the trash mountain, as shown as Fig.3.

Fig.*2* (left): Tripoli landfill (Halwani, Halwani, Amine, & Kabbara, 2020)

Fig.3 (right): Bourj Hammoud landfill (Alieh, 2016)

The green globe headlarifies that Costa Brava's landfill threatens the aviation and the environment and damages the sea as it is considered a pollution source (Taher, 2018). As shown as Fig.4

A landfill place close to the town of Zahle in the Bekaa Valley, Lebanon, showed that garbage removal is one of the numerous infrastructural challenges confronting the Lebanese government (getttyimages , 2010). As shown as Fig.5.

Fig.4: Costa Brava landfill *(Taher, 2018)*

Fig.5: Zahle landfill *(getttyimages , 2010)*

The selected case studies include the main operational landfills in Lebanon and negatively affect the surrounded environment and threat people's health in the nearest residential zones. The next part comprises assessing the buffer zone and the climatic conditions in each of the selected areas to compare and determine the degree of pollution in each area.

5.1. The Buffer Zone Assessment

According to the criteria shown previously that the landfill should maintain a distance from the residential zone, the buffer zone of the four selected areas in the case study is the first step in the assessment that will be applicable in each of these areas to find as a first step the closest residential zone from the landfill in these four cases. The measurement and assessment of the distance between each landfill and the nearest residential area is done depending on google maps measurement to determine the buffer zone between the boundary of the landfill and the closest residential area boundary.

As shown as Fig.6, Tripoli landfill (LF1) is locating close to El-Mina residential area, and by applying a buffer zone between LF1 and this area, it is found that the distance is about (one kilometre).

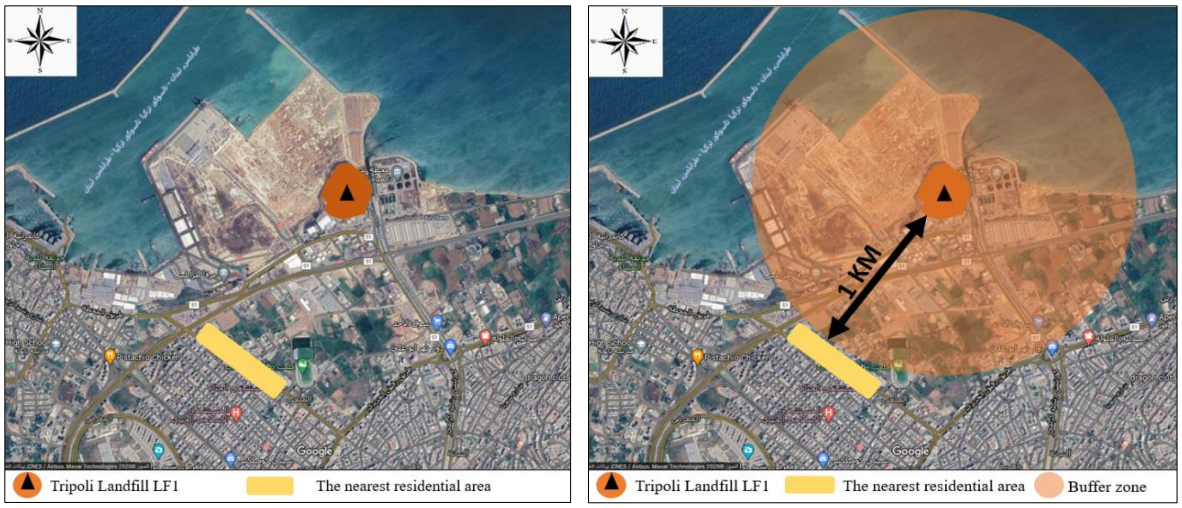


Fig.6: Tripoli Landfill LF1(left) and buffer zone measurement (right). Source: Google Maps, The author

As shown as Fig.7, Bourj Hammoud landfill (LF2) is sitting close to Bourj Hammoud residential area and by applying a buffer zone between LF2 and this area, the distance is found is about (700 m).

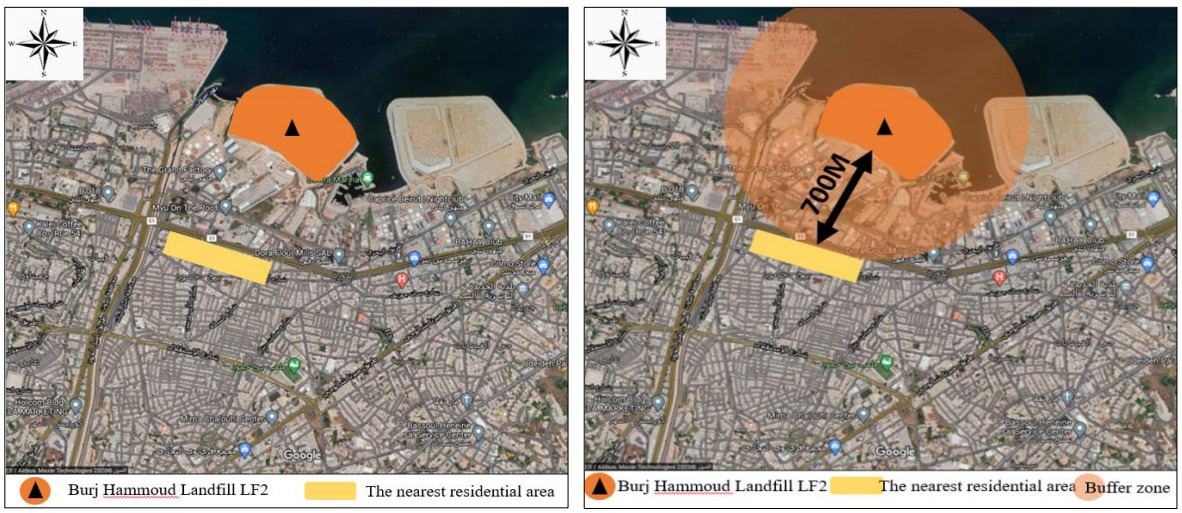


Fig.7: Bourj Hammoud Landfill LF2(left) and buffer zone measurement (right).
Source: Google Maps, The author

As shown as Fig.8, Costa Brava landfill (LF3) is locating close to Chouaifat El-Qoubeh residential area, and by applying a buffer zone between LF3 and this area, it is found that the distance is about (1.3 km).

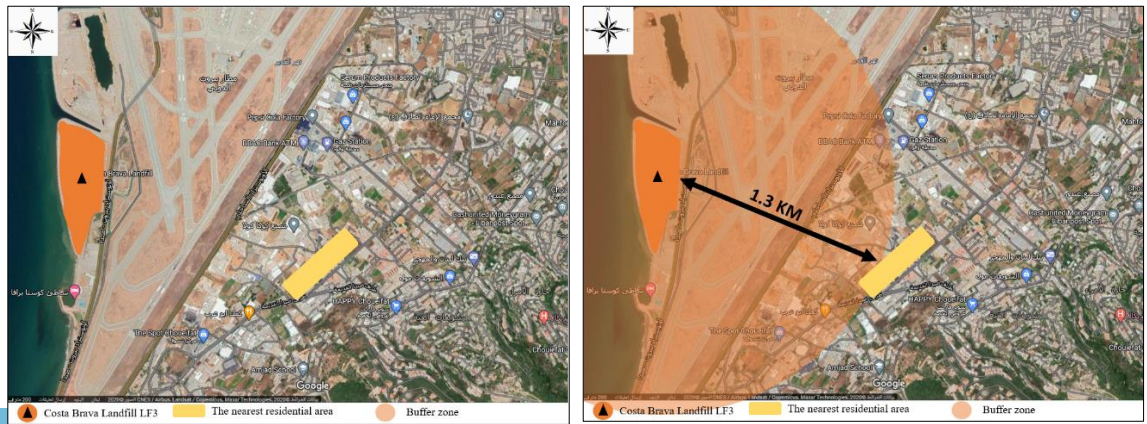


Fig.8: Costa Brava Landfill LF3(left) and buffer zone measurement (right).
Source: Google Maps, The author

As shown as Fig.9, Zahle landfill (LF4) is locating close to the Haouch El Oumaraa residential area, and by applying a buffer zone between LF4 and this area, it is found that the distance is about (500 m).

Fig.9: Zahle Landfill LF4(left) and buffer zone measurement (right). Source: Google Maps, The author

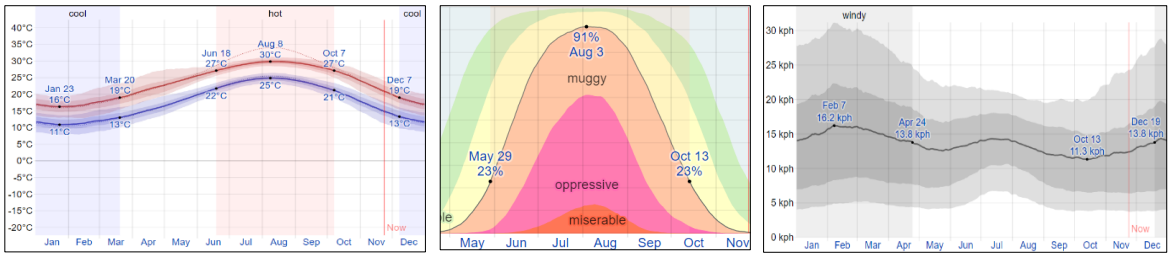
The drawing of the buffer zone for each selected case study helps in the first step of assessing the affected residential area by the landfill pollution and define the distance between the landfill boundary and the nearest residential zone boundary.

5.2. Meteorology Conditions Assessment

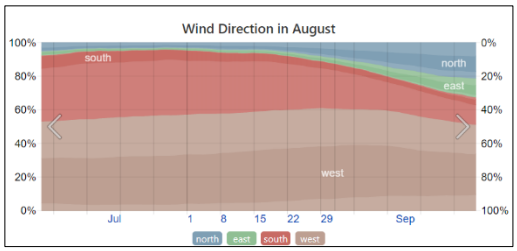
It is mentioned previously that the different meteorological conditions affect the level of pollution caused by landfill, as the increase in the temperature and humidity increase the gases and odour released from landfill. So, in this study, the various weather conditions (temperature, humidity, and wind speed and direction) will be assessed relatively at the same time on the hottest day in summer in Lebanon, which is in August, to evaluate the worst conditions that increase the landfill pollution which negatively affect the residential areas. The rainfall factor is not considered in this study, as the negative impact of this factor is essential in the winter. This study is focused on the negative effect of the weather conditions in the summer, specifically in August when the temperature, humidity, and wind play a significant role in increasing the pollution in the landfills, which increase the negative pollution impact on the inhabitants close to these areas, except the rainfall in this month that is almost none.

The data collected in this part is based on (Weather Spark, 2020), this website provides weather graphs and climate forecasts for any required area.

As shown as Fig.10, the highest temperature in Tripoli city in August is 30c degree, and the relative average humidity level at this time is 91%, and wind speed 13km/h with average wind direction throughout August predominantly from the west with a peak percentage of 61% on August 29.



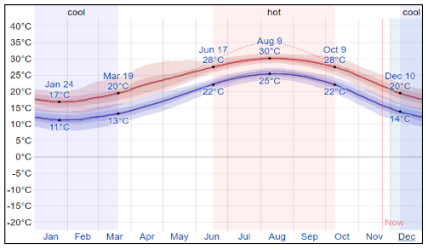
(a) Average high temperature. (b) Average humidity level. (c) Average wind speed.

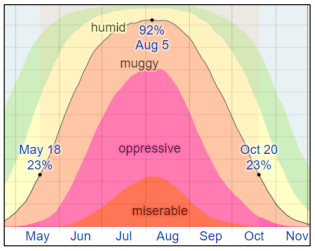


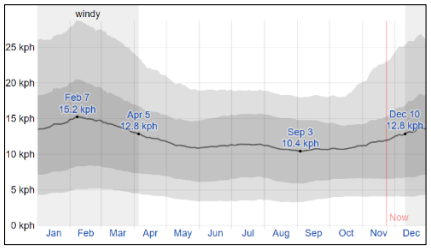
(d) Average wind direction.

Fig.10: Tripoli weather. *(Weather Spark, 2020)*

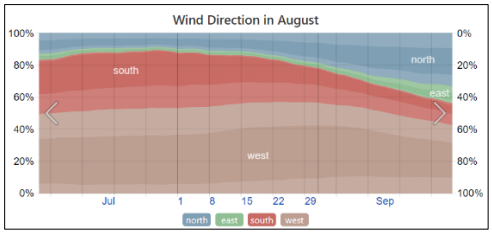
As the coastal area of Bourj Hammoud and Costa Brava areas has similar weather conditions to Beirut city, the weather study for these areas will depend on Beirut weather data. As shown as Fig.11, the highest temperature in Beirut city in August is 30c degree, and the relative average humidity level at this time is 92%, and wind speed 10km/h with average wind direction throughout August predominantly from the west with a peak percentage of 57% on August 22.







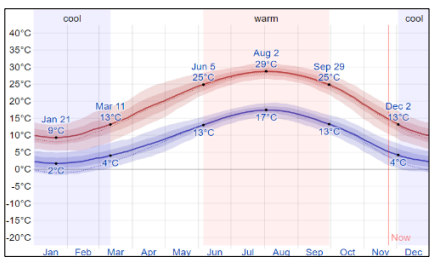
(a) Average high temperature. (b) Average humidity level. (c) Average wind speed.

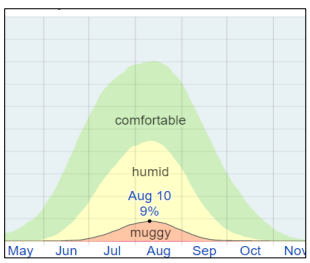


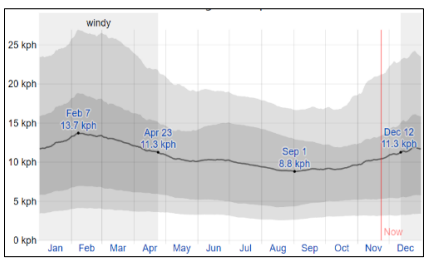
(d) Average wind direction.

Fig.11: Beirut weather. *(Weather Spark, 2020)*

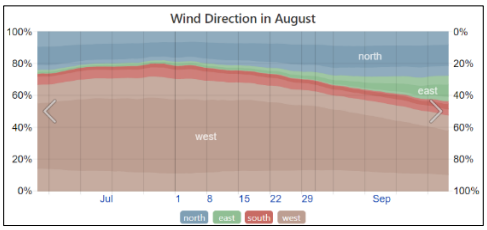
As shown as Fig.12, the highest temperature in Zahle city in August is 28c degree, and the relative average humidity level at this time is 9%, and wind speed 8km/h with average wind direction throughout August predominantly from the west with a peak percentage of 71% on August 3.







(a) Average high temperature. (b) Average humidity level. (c) Average wind speed.



(d) Average wind direction.
Fig.12: Zahle weather. *(Weather Spark, 2020)*

The assessment of the meteorological conditions in the selected case study areas will benefit the study when combining it with the buffer zone's assessment, to be analyzed using the overlay analysis method to achieve the final assessment results.

6. OVERLAY ANALYSIS METHOD AND RESULTS

Overlay analysis is a gathering of techniques used to select the optimum site or select the appropriate modelling. It is a strategy for applying a standard scale of values to assorted and disparate contributions to incorporate analysis. The suitable models distinguish the best or most favored areas for a particular phenomenon (Understanding overlay analysis, 2016).

Map algebra is a cover term for looking at or examining the values inside the cells using algebraic functions, for example, addition, subtraction, multiplication, division, accurate estimations, for example, mean, middle, and standard deviation, relationship tasks, for example, more noteworthy than, not precisely, or equivalent to, and Boolean activities, for example, NOT, AND as well. By inspecting the numerical arrangement of contrasting two raster esteems, connections between the two layers can be determined (Overlay analysis, 2020).

The data collected about the landfill sites and the criteria used to assess the distance between the landfill site and nearest residential area and the meteorological factors that increase the pollution caused by landfill and affect the residential area, all of these data are gathered as indicated in Table 1.

Table 1: Data collected. Source: The author

Landfill	Location	Area	Buffer zone	Temperature	Humidity	Wind S/D	Wind proportion
LF1	Tripoli	60.000 m2	1 Km	30c	91 %	13 Km/h west	61%
LF2	Bourj Hammoud	280.000 m2	0.7 Km	30c	92 %	10 Km/h west	57%
LF3	Costa Brava	150.000 m2	1.3 Km	30c	92 %	10 Km/h west	57%
LF4	Zahle	150.000 m2	0.5 Km	28c	9 %	8 Km/h west	71%

Depending on the provided data, as indicated in Table1, the overlay analysis method is applied as follow:

1. Consider each of (the buffer zone, temperature, humidity, wind speed and proportion) as an independent criterion that affect the assessment of pollution in residential area caused by landfill. Criteria 1: indicates the buffer zone data, Criteria 2: indicates the temperature data, Criteria 3: indicates the humidity data, and Criteria 4: indicates the wind speed data. Criteria 5: indicates the wind proportion data.

2. Suggest a scale value measurement, the set of values is from 0 to 4, the measure of these values is on the scale from: no risk (for value 0), low risk (for value 1), risk (for value 2), moderate risk (for value 3), and high risk (for value 4). The scale value measurement of the landfill pollution is put up precisely to make this study's assessment. As shown as Fig.13
   All the values are considered on the risk scale, as none of the selected case study areas are located out of the landfill buffer zone constrained in five kilometres in some studies to consider the nearest residential area safe. However, numerous studies determine the buffer zone between two to five kilometers to consider the inhabited area safe.
   Also, to make the assessment valid, the meteorological conditions are studied considering the temperature, humidity, and wind at the high level in summer as factors negatively increase pollution from the landfill sites and find out the most risk residential area in this study. For this reason, the assessment is done on the risk scale measurement.
3. The assumption of the value for each criterion is considered as follow:
   Criteria1 (The buffer zone): As the previous studies define, the buffer zone distance between the landfill site and the closest residential area varies from 500 meters to five kilometers as a minimum distance (as mentioned in the literature review part), in addition to the interview conducted in this study that clarifies this distance according to Lebanon regulation to be at least one kilometer. According to the mentioned previously, and as all the selected case studies are in the range that considered in too close distance (in the range of one kilometer and less), the value will be given to this criterion for each selected area as considering the acceptable distance is between one to five kilometers. The value of 4 will be given to the nearest distance (buffer zone) and descending to the furthest.
   In criteria 1: the buffer zone distance assessment shows that the closest landfill to residential area is LF4 for this reason, the value of 4 is given to the high-risk area, LF2 is given the value of 3 as the distance is less than the previous site, LF1 is given the value of 2 as the distance is further than the last and at the least acceptable range, and LF3 is given the value of 1 as the distance is the furthest from the nearest residential zone. As indicated in Table2.
   Criteria 2 (Temperature): As Lebanon has mild temperatures, the hottest summer days (in August) have the highest temperature in these days, it is considered risky as the gas release from landfill in these days is the worst. The value given to this criterion will be 2 for the highest temperature as Lebanon has an average (mild) temperature level, followed by the value of 1 for the least temperature degree.
   In criteria 2: As the temperature does not exceed the 30c degree, LF1, LF2, and LF3 (as they are in the same geographical area and has a similar meteorology condition) are given the value of 2, LF4 is given the value of 1 as the temperature in the hot summer days does not exceed the 28c degree. As indicated in Table2.
   Criteria 3 (Humidity): as Lebanon has a high humidity level in summer days, the value of 4 will be given for the highest humidity level, followed by the less humidity level as a value of 3, and the value of 0 will be given to the acceptable humidity level that is not considered risky.
   In criteria 3: the relative humidity level in the same summer days is considered high. LF2 and LF3 are given 4 as these two areas have the same highest humidity level. LF1 is given the value of 3 as it is slightly lower than the previous, LF4 has given zero as the humidity in the hot summer day does not exceed 9%. As indicated in Table2.
   Criteria 4 (Wind speed): As the highest wind speed in Lebanon is between 25 to 30 kph, and the relatively high wind speed in the same conducted summer days in this study does not exceed 13 kph, the value of 3 will be given to the highest average wind speed in the summer as this wind speed does not considered at the high-risk value, followed by the less descending values.
   In criteria 4, the relative wind speed in the summer is not considered high, as shown previously. LF1 is given the value of 3as the wind speed in this site is higher than the other sites. LF2 and LF3 are given the value of 2. LF4 is given the value of 1. As indicated in Table2.
   Criteria 5 (Wind proportion): depending on the percentage of the wind proportion as indicated in Table1, the highest value of 4 will be given to the highest rate, followed by the less descending values.
   As shown previously, in criteria 5: as the relative wind percentage in the summer is considered high. LF4 is given the value of 4as the wind proportion in this site is higher than the other sites. LF1 is given the value of 3. LF2 and LF3 are given the value of 2. As indicated in Table2.

Table 2: Overlay analysis. Source: The author

Landfill	Criteria 1(buffer zone)	Criteria 2 (temperature)	Criteria 3 (humidity)	Criteria 4 (wind speed)	Criteria 5 (wind proportion)	Results
LF1	2	2	3	3	3	13 = **4**
LF2	3	2	4	2	2	13 = **4**
LF3	1	2	4	2	2	11 = **3**
LF4	4	1	0	1	4	10 = **2**

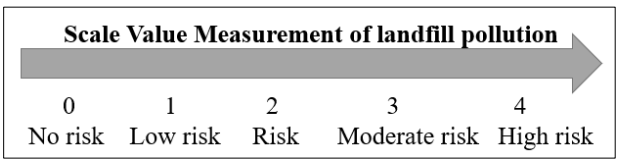


Fig.13: Scale Value Measurement of landfill pollution. Source: The author

The scientific mechanism (as explained at the first of this part) in evaluating the pollution in the selected areas on the risk scale value measurement depends on the overlay analysis method, which combines the results of the applicable criteria for each site to get the final result. The final results are compared to give each final result a value on the scale value measurement as follow: the highest final result value is considered equal to the highest value on the scale value measurement, followed by the less descending numerical values on the same value scale.

As indicated in Table 2, the results show that by combining each criterion's value score for each selected area and making it equal to the amount on the scale value measurement to find out the final results. LF2, LF1 have a high rating as the sum of values is 13 that is the greatest between all the areas. LF2, LF1 have a value of 4 on the scale value measurement, indicating that the landfills sited in Bourj Hammoud and Tripoli are the most pollution source for their nearest residential areas as they have the greatest value rating. The value of 13 is considered like (equal to) the 4 value on the scale value measurement as it is the highest rate. Bourj Hammoud landfill assessment shows that LF2 is a highly risky area.

LF1 has a rating of 13 which means that the Tripoli landfill site is also considered at the high-risk level; the value of 13 is considered equal to the value of 4 on the scale value measurement. Tripoli landfill assessment shows that LF1 is a highly risky area.

LF3 has a rating of 11 which means that the Costa Brava landfill site is also considered risky; it is less risky to Chouaifat El-Qoubeh residential area than the LF2 and LF1 sites. The value of 11 is considered equal to the value of 3 on the scale value measurement. Costa Brava landfill assessment shows that LF3 is a moderate risky area.

LF4 has a rating of 10 which means that the Zahle landfill site is also considered risky; it is a minor risk pollution source to Haouch El Oumaraa residential area than the other selected sites. The value of 10 is considered equal to the value of 2 on the scale value measurement as it is the lowest value rate. Zahle landfill assessment shows that LF4 is a risky area.

The final results show that Lebanon's coastal areas are riskier to the nearest residential zones than the inward site, with less pollution in the nearest residential zone. This proves that the climatic conditions play a significant role in increasing the pollution level, despite that the landfill in zahle (the inward area) is the closest to the residential zone than the other three coastal locations.

7. CONCLUSION

The location of landfill sites in the city is a significant matter that numerous criteria should be considered in selecting this spot, which helps prevent the pollution caused by landfill sites and affect the surrounded areas. This research aims to provide an assessment for the pollution in residential areas produced by landfills located close to these zones. Four selected landfill locations in Lebanon have been analyzed as these landfills are sited near residential areas to make this assessment. The criteria applicated is the distance between each of the selected landfill and the near inhabited zone; this is done using google maps to help determine the locations then providing a buffer zone to measure this distance's suitability. The factors of the meteorological conditions (temperature, humidity, and wind) are studied as well as they affect the pollution in the residential zones; the selection of the different geographical settings in the case study help in assessing the variation in the weather conditions and how this could increase the pollution in the residential spaces. The assessment is done in the four selected areas considering the previous criteria and factors in applying an overlay analysis method to determine the worst affected inhabited area by landfill pollution. According to the results, Bourj Hammoud landfill has the worst effects on Bourj Hammoud residential area, as this area suffers from the close location of the landfill combined with the high-risk weather conditions in the summer, which make this area is the most polluted in addition to the landfill site in Tripoli city as the results show that it has the same degree of pollution, then Costa Brava landfill site, and the less polluted residential area is Haouch El Oumaraa near Zahle landfill site as the results shown in the assessment. This assessment helped to determine the most affected residential area by landfill pollution and the degree of contamination in each of the selected regions and help to conduct the degree of pollution in each area depending on the final results' values that show that the meteorological conditions play a significant role in increasing the pollution effects on the nearest residential areas. According to this study, the pollution degree is higher in the coastal region than the inward area as the climatic conditions (as temperature and humidity) are worst in the coastal zone in the summer than the inward area, which increase the pollution by landfills that affect the nearest zones.

Recommendation

This research intended to benefit from the regulations that control the establishment of a new landfill site in the city in specific the criteria related to the residential zones to help finding out the degree of contamination in the surrounded area, especially the residential areas. This step could help in future the urban planner of the city when deciding to plan a new residential zone, by depending on this study as adopting a new method to evaluate the pollution degree in a new suggested planned region in case of the existence of a landfill site close to the new planned residential zone. This work should be combined with the environmental and geological, and meteorological professionals to achieve the best and adequate results. In this research, the studied factors include the distance between the locations of the landfill site and the residential area is considered as a significant factor that influences the people in the regions surrounded that the much the area is close to the landfill location the much the people will be affected by the landfill pollution. In addition to the climatic factors that play a significant role in increasing the pollution forms in the landfill as the increase of the temperature degrees in summer, the high humidity level, the wind speed, and direction that is considered an essential factor in transforming the odours and gas releases from the landfill. From this point of view, future studies could benefit from the method adopted in this research and improve it by combining it with other professions participations to reach the optimum results in evaluating the degree of pollution caused by landfill in any new planned area.

REFERENCES

- Abbas, s., Chaaban, J., Al-Rabaa, A.-R., & Shaar, A. (2017). Solid Waste Management in Lebanon: Challenges and Recommendations. *Journal of Environment and Waste Management*.
- Overlay analysis. (2020). In *Learn GiS.*
- Abu Qdais, H., & Shatnawi, N. (2019). Assessing and predicting landfill surface temperature using remote sensing and an artificial neural network. *International journal of remote sensing*.
- Ahlbäck, J. (2011). *Green jobs assessment in Lebanon.*
- Ahmad, S. Z., & Ahamad, M. S. (2020). Comprehensive Spatial Criteria and Parameters for Sustainable Landfill. *IOP Conference Series: Earth and Environmental Science.*

- Alieh, Y. (2016, June). Khoury Contracting lowest bidder in Burj Hammoud tender - Landfill to contain 1.4 million tons over four years.
- AZZI, E. (2017). *Waste Management Systems.*
- Board, C. P. (2017). *GUIDELINES ON THE PROVISION OF BUFFER ZONE AROUND WASTE PROCESSING AND DISPOSAL FACILITIES.*
- Boswall, J. (2019). *Lebanon: the state of waste.*
- El-Hoz, M. (2017). *Current Situation and Challenges to Address on the Landfill of Tripoli.*
- Environment, M. o. (2016). *LANDFILL CRITERIA FOR MUNICIPAL SOLID WASTE.*
- getttyimages . (2010). Lebanon - Recycling.
- Halwani, J., Halwani, B., Amine, H., & Kabbara, M. B. (2020). Waste Management in Lebanon—Tripoli Case Study. In *Waste Management in MENA Regions* (pp. 223-239).
- Hidayati, R. M., Utomo, S. W., & Kusnoputranto, H. (2020). Health Risks of People Living Close Cipayung Depok Landfill Due to Hydrogen Sulfide Exposure: Respiratory Problems and Malodor Perceptions. *Indian Journal of Public Health Research & Development*.
- Hilal, N., Fadlallah, R., Jamal, D., & El-Jardali, F. (2015). *Approaching the Waste Crisis in Lebanon: Consequences and Insights into Solutions.*
- Islam, M., Kashem, S., & Morshed, S. (2020). Integrating spatial information technologies and fuzzy analytic hierarchy. *Elsevier*.
- Jadam, J. (2010). Solid Waste. In *State and Trends of the Lebanese Environment.*
- Jadam, J., El-Jisr, K., & Stephan, R. (2011). *State and Trends of the Lebanese Environment.*
- Kamel, A., & Hasan, B. (2018). Sustainable Geographic Information System-Based Map for Suitable Landfill Sites in Aley and Chouf, Lebanon.
- Lewis, E. (2020). Out of sight, out of mind: Lebanon expands landfill to clear garbage from streets.
- Mainul Sk, M., Ali, S. A., & Ahmad, A. (2020). Optimal Sanitary Landfill Site Selection for Solid Waste Disposal in Durgapur City Using Geographic Information System and Multicriteria Evaluation Technique. *Journal of Cartography and Geographic Information*.
- Maroun, C. E. (2019). EJAtlas - Global Atlas of Environmental Justice - Saida Garbage Mountain, Lebanon.
- Meraaby, T. (2019). EJAtlas - Global Atlas of Environmental Justice - Costa Brava Landfill, Lebanon.
- Mikhael, M., & Saadeh, L. (2015). *Solid Waste Management in Lebanon.*
- Mouallem, H. E. (2019). EJAtlas - Global Atlas of Environmental Justice - Bar Elias Litani Pollution, Lebanon.
- Moughalian, C. (2019). EJAtlas - Global Atlas of Environmental Justice - Bourj Hammoud Garbage Mountain, Lebanon.
- Munawar, E., & Fellner, J. (2013). *Guidelines for Design and Operation of Municipal Solid Waste Landfills in Tropical Climates.*
- Nader, M., Jazi, M., Abou Dagher, M., & Indary, S. (2012). *Environmental Resources Monitoring in Lebanon - ERML.*
- Oxford, U. (2016). Living near a landfill could damage your health.
- Sfakianaki, E., & Kasis , G. (2020). Identification and evaluation of suitable locations for waste management sites. *International Journal of Decision Sciences Risk and Management*.
- Singh, S., & Farswan, S. (2019, August). Landfill-Solution or a Bigger Problem to the Environment. *Research Gate*.
- STREG. (2017). *Support to Reforms – Environmental Governance (StREG) Programme.*
- SweepNet. (2014). *Country report on the solid wastemanagement in LEBANON.* Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.
- Tadmouri, R., & Seif, H. (2019). Sustainability Management of Solid Waste in Tripoli Lebanon Landfill. *ResaerchGate*.
- Taher, A. (2018). Lebanon: Environmental Associations Say 'Costa Brava Landfill' Threatens Aviation Safety.
- Tran, L. H., Murayama, T., Enomoto, C., & Nishikizawa, S. (2020). Impact of Odor from a Landfill Site on Surrounding Areas: A Case Study in Ho Chi Minh City, Vietnam. *Environment and Natural Resources Journal*.

- *Understanding overlay analysis*. (2016). Retrieved from Esri.
- Vidovic, M. (2017). *METEOROLOGICAL CONDITIONS AFFECTING THE DISPERSION OF LANDFILL ODOR COMPLAINTS.*
- *Weather Spark*. (2020). Retrieved from Cedar Lake.