## Research Article
# The use of DRASTIC Index and Simple Matrix Techniques to Assess the Environmental Impact of Akaider Dumpsite Area/Jordan

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**Abstract:** EIA are needed to avoid adverse impacts and to ensure long term benefits which lead to sustainable development. There are several techniques to conduct an EIA. Among these techniques include checklists, Matrices and overlay. DRASTIC index is considered an important methodology for studying groundwater vulnerability. In this research study, a simple matrix technique was adopted to investigate the Environmental Impacts of Akaider dumpsite on the surrounding environment. Nine environmental parameters (Groundwater, surface water, air, soil, land use, industry, public health, heritage and historical sites and socio-economic situation) were studies to see the impact of the dumpsite on their quality. It was found that the dumpsite might pose a major threat to these parameters. Also, DRASTIC index was used to investigate groundwater vulnerability to contamination in the area. It was found that the dumpsite is located within a moderate vulnerability zone. This means that groundwater in the underlying groundwater basins in not completely save and might be contaminated in the future.

**Keywords:** Akaider, DRASTIC, EIA, groundwater, GIS, Jordan, simple matrix

## INTRODUCTION

Economic, social and environmental changes are inherent to development. Whilst development aims to bring about positive change it can lead to conflicts. In the past, the promotion of economic growth as the motor for increased well-being was the main development thrust with little sensitivity to adverse social or environmental impacts. There is a need to avoid adverse impacts and to ensure long term benefits led to the concept of sustainability. This has become accepted as an essential feature of development if the aim of increased well-being and greater equity in fulfilling basic needs is to be met for this and future generations (Dougherty *et al*., 1995).

EIA is potentially one the most valuable, inter disciplinary, objective decision-making tools with respect to alternate routes for development, process technologies and project site. It is an anticipatory mechanism which establishes quantitative values for parameters that indicate the quality of the environment and natural system before, during and after the proposed development activity, thus allowing measures ensuring environmental compatibility with economic efficacy (Khanna and Kondawar, 1991).

Impact identification bring together project characteristics and baseline environmental characteristics with the aim of ensuring that all potentially significant environmental impacts (adverse or favorable) are identified and taken into account in the EIA process. A wide range of methods have been developed. The methods are divided into the following major categories (Glasson *et al*., 2005):

- **Checklists:** Most checklists are based on a list of special biophysical, environmental, social and economic factors may be affected by a development. The simple checklists can only help to identify impact and ensure that impacts are not overlooked. Checklists do not usually include direct cause-effect links to project activities. Nevertheless, they have the advantage of being easy to use (Sassaman, 1981; Canelas *et al*., 2005; Pinho *et al*., 2007; Badr *et al*., 2011; Wagh and Gujar, 2012).

- **Matrices:** Matrices are the most commonly used method of impact identification in EIA. Simple matrices are merely tow-dimensional charts showing environmental components on one axis, and development actions on the other. They are, essentially, expansions of checklists that acknowledge the fact that different components of a development project (e.g., construction, operation, decommissioning; building, access road) have different impact. Actions likely to have an impact on an environmental component are identified by placing a cross in the appropriate cell (Parker and Howard, 1977; Clark *et al*., 1979; Stull *et al*., 1987; Berube, 2007).

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- **Overlay maps:** Overlay maps have been used in environmental planning. A series of transparencies is used to identify. Predict, assign relative significance to and communicate impact, normally at a scale larger than local. A base map is prepared, showing the general area within which the project may be located. Successive transparent overlay maps are then prepared for individual environmental components that. In the opinion of experts, are likely to be affected by the project (e.g., agriculture, woodland, noise). The project's degree of impact on the environmental feature is shown by the intensity of shading, with darker shading representing a greater impact. The composite impact of the project is found by superimposing the overlay maps and noting the relative intensity of the total shading. Unshaded area is those where a development project would not have a significant impact (Shopley and Fuggle, 1984, Smh and Chandra, 2004, Zelenakova and Zvijakova, 2011, Akintunde and Olajide, 2011).

Groundwater vulnerability mapping is based on the idea that some land areas are more vulnerable to groundwater contamination than others (Piscopo, 2001). There are several methods used to assess groundwater vulnerability to contamination. Among these methods; the DRASTIC index which is considered an indicator for pollution potential (Merchant, 1994). Determination of the DRASTIC index involves multiplying each factor weight by its point rating and summing the total (Knox *et al.*, 1993). The DRASTIC methodology was developed by the US

Environmental Protection Agency. DRASTIC is an acronym for:

$$\text{Pollution Potential} = D_r \times D_w + R_r \times R_w + A_r \times A_w + S_r \times S_w + T_r \times T_w + I_r \times I_w + C_r \times C_w \quad (1)$$

where,
D : Depth to water table
R : Net Recharge
A : Aquifer media
S : Soil media
T : Topography
I : Impact of the vadose zone
C : Hydraulic Conductivity of the aquifer
r : Rating
w : Weight

Several studies have used the DRASTIC model within a GIS environment (Evans and Mayers (1990); Secunda *et al.* (1998); Fritch *et al.* (2000), Piscopo (2001); Al-Adamat *et al.* (2003); Sener *et al.* (2009); Al-Amoush *et al.* (2010); Singh *et al.* (2010).

This study aims to assess the Environmental impact of Akaider dumpsite-Jordan using the simple matrix technique in combination with groundwater vulnerability to contamination using GIS and DRASTIC.

## RESEARCH METHODS

**Investigated site (Akaider dumpsite):** Akaider dumpsite is located to the North East of Mafraq City. The site is located *ca* 5 km to the West of the main road
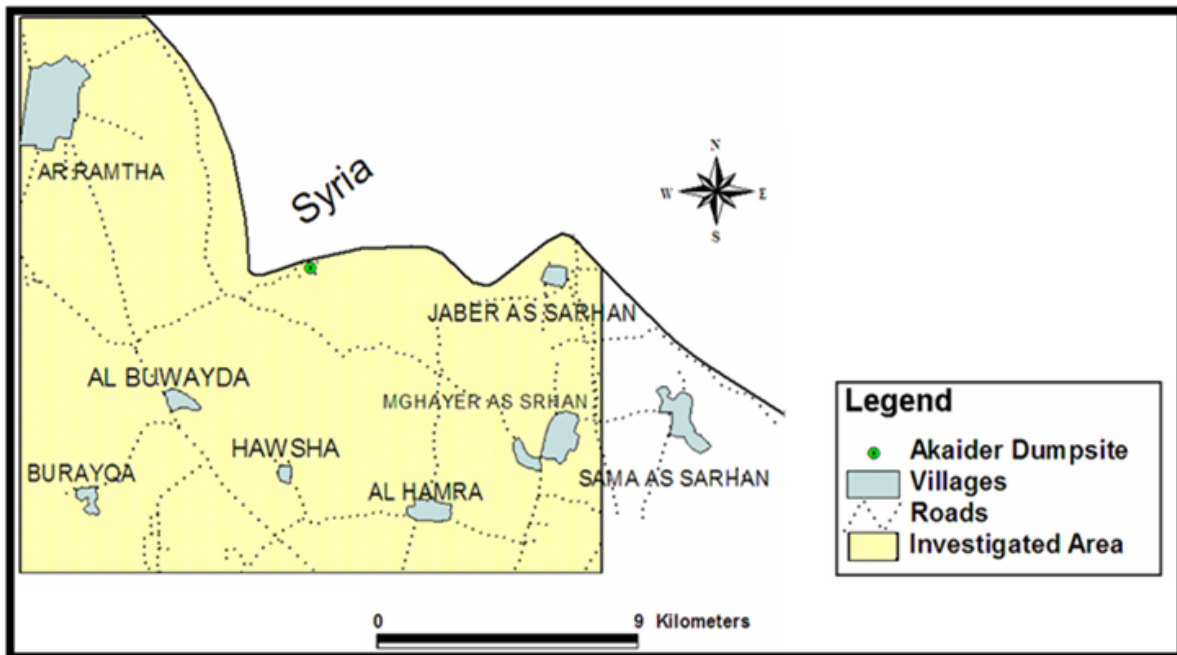


Fig. 1: The location of Akaider dumpsite

to Syria (Zarqa–Jaber Highway) and 2.5 km from the closest settlement (Fig. 1). The dumpsite is only 400 m away from the Syrian border and it is located at the following coordinates: N: 32 30 54.48 E: 36 06 38.49. The investigated area in this research for the Akaider dumpsite is covering an area of 263 km².

The site is currently receiving a range of wastes from diverse sources, including Municipal and Medical wastes (Al-Meshan, 2005). According to Al-Meshan (2005), the site has an area of 80.6 ha and has a capacity of receiving around 350 tones per day. The site receives heterogeneous wastes including municipal, industrial and medical waste from Irbid and Mafraq areas. The disposal method at this site is based what is called "the Sandwich method" (Al-Meshan, 2005).

The annual rainfall in the area varies between 100 mm in the East to around 250 mm in the West. The surface geology of the area is dominated with Chalk, Marl bituminous Limestone, Phosphrite, Shale dolomite, Chert, Terrestrial, Fluviatile and Lacustriane sediments. The soil texture in Akaider dumpsite area is classified into three classes; Sandy loam, Silty Clay and Silty loam.

**Data collection:** A range of secondary data were required in order to provide quantitative information for the groundwater vulnerability assessment including the distribution of soil types, depth to groundwater and the spatial rainfall distribution. These data were derived from a variety of sources and were obtained in a range of formats. These data included Geology, Depth to Groundwater, Topography, Soil, Rainfall and Well data.

All these data were converted into GIS format in order to perform the necessary operations that will produce the overall DRASTIC index based on the above mentioned Equation.

## DATA ANALYSIS AND RESULTS

**The DRASTIC index for akaider dumpsite:** The DRASTIC index was calculated in the ArcGIS environment to map the groundwater vulnerability of the investigated site and the above Equation was used to produce the DRASTIC index. However, hydraulic conductivity data were not available for the investigated areas. While most of the data required for the calculation of the index were directly available from the GIS data sets, the estimated recharge values were computed from a combination of slope, soil permeability and rainfall following the methods of Piscopo (2001) as shown in Table 1.

The other DRASTIC parameters (Depth to groundwater, Aquifer Media, Soil, Topography and the Impact of vadose zone) are shown in Table 2 which is based on Knox *et al.* (1993), Al-Farajat, (2002) and Al-Adamat *et al.* (2003). Table 3 shows the DRASTIC qualitative categories based on Al-Farajat, (2002).

In order to calculate the recharge value (Rr×Rw), a Digital Elevation Model (DEM) of the study area was generated from the contour map. The slopes in the study area were then derived from the DEM and classified according to the criteria given in Table 1a. The resulting slope map was converted into a grid coverage taking into consideration that the pixel values in this grid coverage are based on the slope ratings. The

Table 1: The recharge ratings and weight for the study area (modified from Piscopo, 2001); (Soil permeability is based on USDA (United State Department of Agriculture), 1994)

| Slope | | Rainfall | | Soil Permeability | | Recharge value | |
|---|---|---|---|---|---|---|---|
| Slope (%) | Factor | Rain (mm) | Factor | Range | Factor | Range | Rating |
| < 2 | 4 | <500 | 1 | Moderate/Rabid | 6 | 9-11 | 8 |
| 2-10 | 3 | | | Moderate | 4 | 7-9 | 5 |
| 10-33 | 2 | | | Low | 2 | 5-7 | 3 |
| | | | | | | Weight | 2 |

Table 2: The weights and ratings for the DRASTIC index (Excluding the Hydraulic conductivity and the Recharge)

| Parameters | Weight | DRASTIC rating | |
|---|---|---|---|
| Depth to groundwater | 5 | >30.5 meter | 1 |
| Aquifer media | 3 | Chalk, Marl Bituminous Limestone, Phosphrite | 8 |
| | | Terrestrial,fluviatile and lacustriane sediments | 6 |
| | | Limestone, Marl, Shale Dolomite and Chert | 5 |
| Soil media | 5 | Sandy loam | 6 |
| | | Loam | 5 |
| | | Silty loam | 4 |
| Topography (slope) | 3 | 0-2% | 10 |
| | | 2-6 % | 9 |
| | | 6-12 % | 5 |
| | | 12-18 % | 3 |
| | | >18 % | 1 |
| Impact of vadose zone | 4 | Chalk, Marl Bituminous Limestone, Phosphrite | 3 |
| | | Terrestrial,fluviatile and lacustriane sediments | 6 |
| | | Limestone, Marl, Shale Dolomite and Chert | 3 |

Table 3: DRASTIC Qualitative Categories (Based on Al-Farajat, 2002)

| Drastic Qualitative Category (Drastic Index) | | | |
|---|---|---|---|
| Low | Moderate | High | Very high |
| 1-100 | 101-140 | 141-200 | >200 |

soil map was classified into two classes based on the criteria given in (Table 1b) and was then converted into grid coverage. This process was essential in order to perform arithmetic operations within the GIS. Finally, both grids were added together with the rating value of the rainfall, which is equal to 1 in the study area (Table 1c). Recharge was then calculated using the following Equation based on Piscopo, 2001):

$$\text{Recharge value} = \text{Slope+Rainfall+Soil}$$

The resulting map was then classified according to the criteria given in (Table 1d) and multiplied by the weighting factor of the recharge parameter (Fig. 2)

The depth to groundwater in the study area was significantly greater than 30 m in all wells (WAJ (Water Authority of Jordan), 1995). The depth index was obtained as a result of multiplying Dr×Dw based on the weighting system of Knox *et al.* (1993) (Table 2). A constant number for both sites of 5 will be added to the final calculation.

As shown in Table 2 and based on the geological description of the investigated, the aquifer media was classified as:

- Chalk, marl bituminous limestone, phosphrite, and limestone
- Limestone, marl, shale dolomite and chert
- Terrestrial, fluviatile and lacustriane sediments (Fig. 2)

The soil map was classified into three classes based on the ratings for the soil texture. The vector layer of soil was converted to a raster grid and multiplied by the weighting factor of the soil media which has produced the map of Sr×Sw (Fig. 2).

In Table 2, the topographic parameter is sub-divided into 5 classes. The slope index, which was derived from the DEM to find the ratings for recharge, was reclassified and then converted into grid coverage and multiplied by the topographic weight (Fig. 2). The study area has only 4 classes where no areas with slope of more that 18%.

The geological description of Akaider dumpsite area indicated the existence of:

- Chalk, marl bituminous limestone, phosphrite, and limestone
- Limestone, marl, shale dolomite and chert
- Terrestrial, fluviatile and lacustriane sediments

Based on Table 2, the Ir was multiplied by Iw for the site based on its geology (Fig. 2).
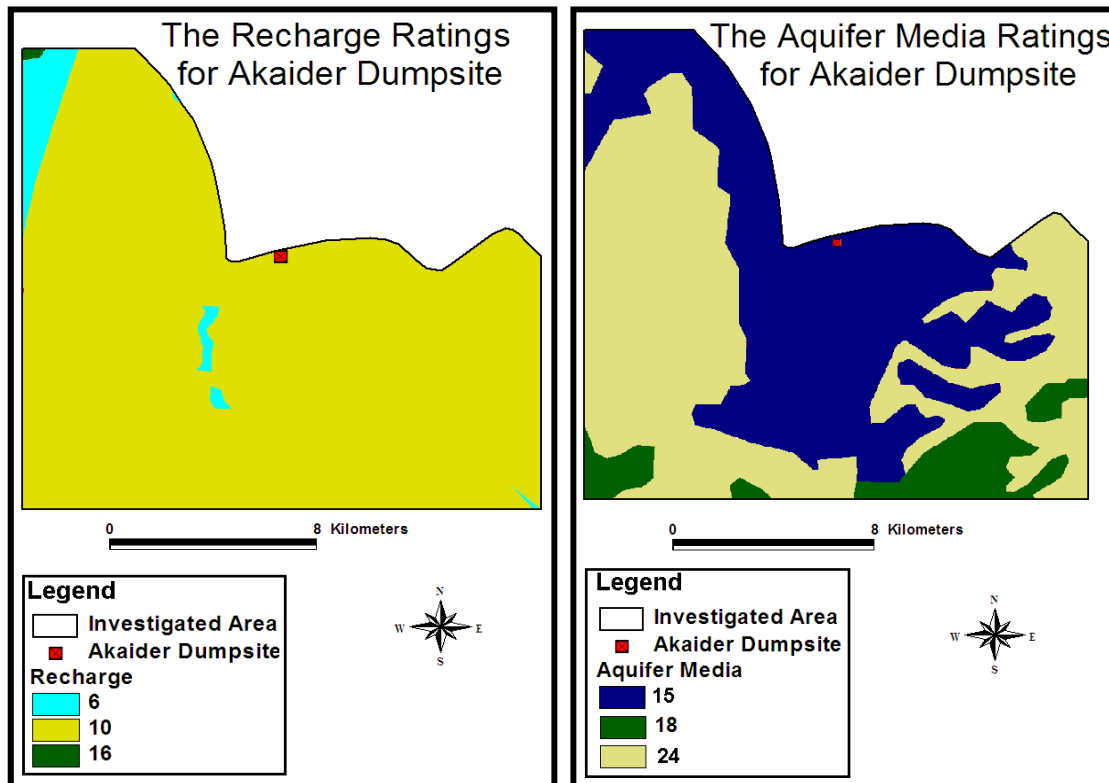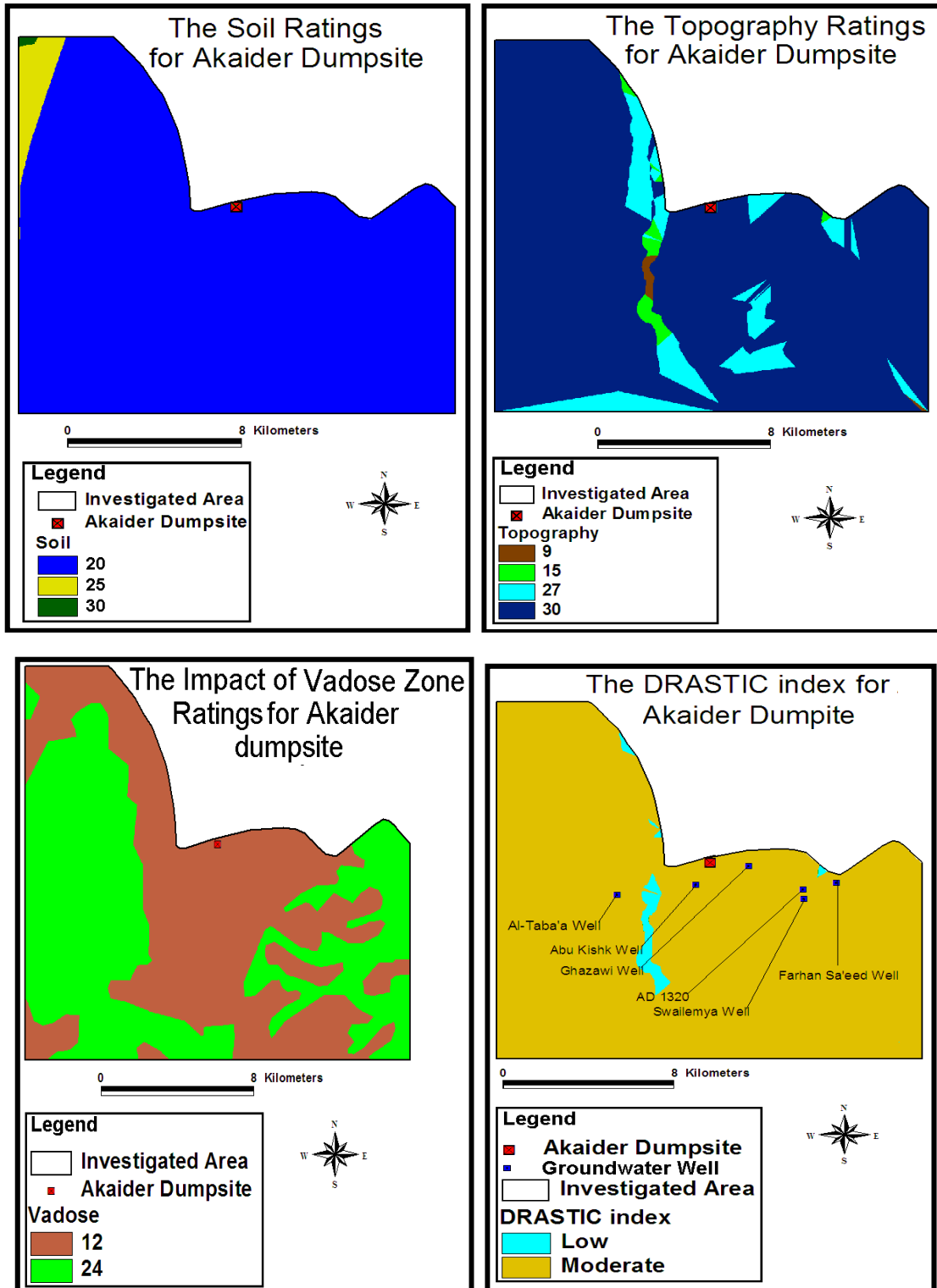
Fig. 2: The DRASTIC parameters and the final DRASTIC index of the surrounding area of Akaider dumpsite

The GIS coverage were all in raster format and values for each overlay were summed in ArcGIS according to the pixel value of each area that resulted from multiplying the ratings with its appropriate DRASTIC weight (Table 2). A fixed number of 5 were added to the final raster grid coverage. This number represents the depth to groundwater (Dr×Dw).

The DRASTIC equation listed above was used in ArcGIS to calculate the total DRASTIC index for the study area. The outcome of this calculation was then
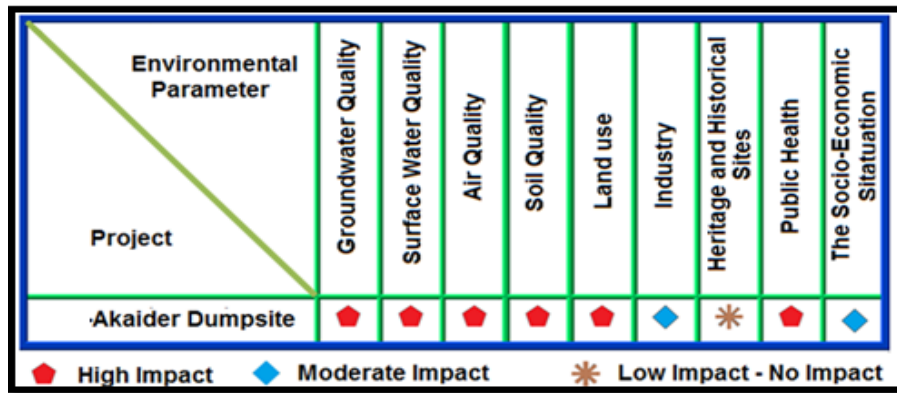
Fig. 3: The simple matrix for Akaider dumpsite



Fig. 4: Photographs of solid and liquid wastes at Akaider dumpsite

classified according to Table 3. The result of this classification is shown in Fig. 2.

**The simple matrix for akaider dumpsite:** The simple Matrix technique was applied to investigate the environmental impact of Akaider dumpsite based on environmental 9 parameters:

- Groundwater quality
- Surface water quality
- Air quality
- Soil quality
- Land use
- Industry
- Heritage and historical sites
- Public health and
- The socio-economic situation

The impact of the dumpsite on these parameters was classified into 3 classes:

- High
- Moderate and
- Low (No impact)

Figure 3, illustrates the simple matrix for Akaider dumpsite.

**Groundwater quality**: Based on the groundwater vulnerability map for the area surrounding the dumpsite (Fig. 2). The impact of the dumpsite on groundwater quality in the area is considered high due to the existence of liquid waste in combination with the solid wastes leachate that might include heavy metals.

**Surface water quality:** It was assumed that the impact of the dumpsite on surface water quality in the area will be high due to the following facts:

- The solid wastes from the dumpsite and/or trucks carrying these wastes might reach nearby streams (Wadis) which might lead to contaminating the surface water running in these streams in winter season.
- The form of rainfall in the area is dominated by thunderstorm which might lead to massive runoff in short duration. This could cause carrying huge amounts of solid and liquid wastes to the streams in the area. According to Al-Ghad newspaper (15-August-2006), a huge amount of liquid waste reached the Syrian farms during a rainfall event which contaminated the surface water and soil in these farms. This forced the Jordanian government to compensate the Syrian farmers for this damage. Figure 4 shows the solid and liquid wastes in Akaider dumpsite.

**Air quality:** Air quality in the surrounding area is affected by the followings:

- Odors resulting from the dumpsite,
- Smoke resulting from the combustion of waste,
- The dust volatiles from the dumpsite and
- Pesticides that are sprayed to limit the spread of insects and mosquitoes that resides in the dumpsite,

These pollutants affect the quality of the air and thus affect living organisms, including humans. The

Fig. 5: Photographs of burning solid wastes at Akaider dumpsite



Fig. 6: Google Earth imagery of 2013 for Akaider dumpsite

following figure (Fig. 5) show the smoke resulting from the combustion of waste.

**Soil quality:** The dumpsite has greatly affected the soil quality in the surrounding area where land suitable for agricultural activities has declined by more than 75% (1000 to 225 ha) according to Ad-Dustour newspaper (24-August-2011). The dumpsite caused a decline in land productivity of fruits, olives, vegetables, wheat and barley that used to be grown in the area.

**Land use:** The dumpsite has affected the land use in the surrounding area. Odors emitted from the dumpsite have prevented any new human settlements in the area. Wastes have caused a decline to the land productivity which also prevented further agricultural activities. The dumpsite has caused a decline to the agricultural land and its potential threat to contaminating groundwater and surface water quality might lead to damaging any existing agricultural activities in the area. Figure 6 shows a Google Earth image of the dumpsite and its surrounding land uses.

**Industry:** It was assumed that the dump has a moderate impact on industry in the area. The pollutants resulting from the dumpsite might limit the industrial activities in the area. There is a potential for having industrial activities in the area that utilize some of the solid wastes in the dump (Recycling of Plastic, Glass and metals).

**Heritage and historical sites:** Since there are no heritage and historical sites in the surrounding area of the dumpsite, it was assumed that dumpsite has no affects on such environmental parameter.

**Public health:** The dumpsite has been assumed to have a major threat to the public health. According to news report, three workers in the dumpsite have been affected by hepatitis B and C viral. Also, 57 workers filed a complaint to the concerned authorities about the suffering of dozens of them from the endomorphy, chest and psychological diseases. Also, they complain about the existence of other illness conditions such as diarrhea, headache, redness of the eyes, mental depression and sexual impotence, shortness of breath and skin diseases. (Ad-Dustour newspaper, 24 August, 2011).

The burning of solid wastes in the dumpsite might lead to producing toxic gases such as mercury, which leads to the creation of a feeling of tiredness and fatigue, headache, dizziness, kidney damage, digestive disorders, and health crises in the lungs which might lead to premature death.

**The socio-economic situation**: Based on all environmental parameters discussed in this research, it appears that the dumpsite has a high impact on the socio-economic situation in the area. It affects water resources, soil, land use which affect human livelihood. It also causes diseases that have negative impacts on the social and economic situations of people living nearby the dumpsite and people working in the dumpsite.

### CONCLUSION AND RECOMMENDATIONS

It was found that Akaider dumpsite poses a major threat to 8 environmental parameters in the area including the water resources, air, soil, land use and public health. This might lead to series consequences on the socio-economic situation in the area and negatively impact the livelihood of the local communities surrounding the dumpsite.

It was also found in this paper that the dumpsite is located with a moderate vulnerability zone. This means that groundwater in the underlying groundwater basins in not completely save and might be contaminated in the future. However, with further precautions and measures, the risk of groundwater contamination could be prevented or at least minimized.

Based on that it is recommended that the dumpsite must have a better management in order to avoid any negative impacts on the environment. It is recommended that the following points should be considered to have a better onsite management of the dumpsites:

- Major contamination of the environment can be avoided through specifically designed and managed disposal of wastes from industries such as smelting, electroplating and tanning industries.
- Control of the type and amount of waste placed in the dumpsite is a basic measure to protect the environment.
- Waste that is considered hazardous due to its ignitability, corrosivity, reactivity, toxicity and carcinogenicity (Sharma and Lewis, 1994) must not accepted at the dumpsites, but is separated and removed for specialized disposal.
- Separation or sorting of waste for reuse or recycling (e.g., paper, bottles, cans) is a key measure in controlling and reducing waste going to the dumpsite.
- Raising the public awareness about the importance of environmental protection. This is the prerequisite for avoidance strategies that require waste separation at the household level.
- Waste incineration can be an effective strategy to substantially reduce the amount of waste that goes into a dumpsite.
- Further planning aspects critical to potential groundwater contamination are the size of a waste disposal facility and the rate at which refuse is deposited
- Containment is an approach that could protect groundwater resources from the leachate generated by waste disposal. It requires that all liquid produced within the dumpsite are contained and collected for treatment. This will minimize production of leachate by restricting access of rainwater to the waste, and to prevent its migration from the dumpsite. This is accomplished by enclosing the waste in artificial lining systems consisting of a dumpsite liner and cap. As a consequence, leachate drainage systems, containment ponds and leachate treatment facilities are essential additional components of modern containment landfills.
- Periodic monitoring of groundwater quality using a system of wells located both upstream and downstream of a dumpsite.
- Maintenance of an inventory of all dumpsites including that no longer in operation is critical since the risks posed by the dumpsite to the quality of local groundwater remain for decades. Where poorly sited, designed or constructed landfills or informal dumps are identified as hazard, an approach to remediation is to discontinue their use, cover them and, where necessary, monitor downstream groundwater quality.

## REFERENCES

Akintunde, M.A. and A. Olajide, 2011. Environmental impact assessment of Nigerian National Petroleum Corporation (NNPC) Awka mega station. Amer. J. Sci. Ind. Res., 2(4): 511-520.

Al-Farajat, M., 2002. Hydrogeoecosystems in Aqaba, Impacts of Landuse and Vulnerability against Groundwater Pollution. Ph.D. Thesis, Wuerzburg, Germany, pp: 220.

Al-Adamat, R.A.N., I.D.L. Foster and S.M.J. Baban, 2003. Groundwater vulnerability and risk mapping for the Basaltic aquifer of the Azraq basin of Jordan using GIS, remote sensing and DRASTIC. Appl. Geograp., 23: 303-324.

Al-Amoush, H., N. Atalla Hammouri, F. Zunic and E. Salameh, 2010. Intrinsic vulnerability assessment for the alluvial aquifer in the Northern part of Jordan Valley. Water Resour. Manage., 24: 3461-3485.

Al-Meshan, O., 2005. Location Criteria for domestic and Hazardous Waste disposal to landfill in the Jordanian Badia using GIS. Unpublished Ph.D. Thesis, Coventry University, UK.

Badr, E.A., A.A. Zahran and M. Cashmore, 2011. Benchmarking performance: Environmental impact statements in Egypt. Environ. Impact Assess. Rev., 31: 279-285.

Berube, M., 2007. Cumulative effects assessments at hydro-Quebec: What have we learned? Impact Assess. Proj. Appraisal, 25(2): 101-109.

Canelas, L., P. Almansa, M. Merchan and P. Cifuentes, 2005. Quality of environmental impact statements in Portugal and Spain. Environ. Impact Assess. Rev., 25: 217-225.

Clark, B.D., K. Chapman, R. Bisset and P. Wathern, 1979. Environmental Impact Assessment. In: Lovejoy, D. (ed.), Land-use and landscape planning, Leonard Hill, Glasgow, pp: 53-87.

Dougherty, T.C., A.W. Hall and H.R. Wallingford, 1995. Environmental impact assessment of irrigation and drainage projects. 53 FAO Irrigation and Drainage Paper, Retreieved form: http://www.fao.org/docrep/v8350e/v8350e00.HTM.

Evans, B.M. and W.L. Myers, 1990. A GIS-based approach to evaluating regional groundwater pollution potential with DRASTIC. J. Soil Water Conservat., 45(2): 242-245.

Fritch, T.G., C.L. Mcknight, J.C. Yelderman and J.F. Arnold, 2000. An aquifer vulnerability assessment of the paluxy aquifer, central Texas, USA, using GIS and a modified DRASTIC approach. Environ. Manage., 25(3): 337-345.

Glasson, J., R. Therivel and A. Chadwick, 2005. Introduction to Environmental Impact Assessment. 3rd Edn., Routledge, London.

Khanna, P. and V.K. Kondawar, 1991. Application of remote sensing techniques for environmental impact assessment. Current Sci., 61(3): 252-25.

Knox, R.C., D.A. Sabatini and L.W. Canter, 1993. Subsurface Transport and Fate Processes. Lewis Publishers, USA.

Merchant, J.M., 1994. GIS-Based groundwater pollution hazard assessment: A critical review of the DRASTIC Model. Photogrammet. Eng. Remote Sensing, 60(9): 1117-1127.

Parker, B.C. and R.V. Howard, 1977. Te first environmental monitoring and assessment in Antarctica: The dry valley drilling project. Biol. Conservat., 12(2): 163-77.

Pinho, P., R. Maia and A. Monterroso, 2007. The quality of portuguese environmental impact studies: The case of small hydropower projects. Environ. Impact Assess. Rev., 27: 189-205.

Piscopo, G., 2001. Groundwater vulnerability map, explanatory notes, Castlereagh Catchment, NSW. Department of Land and Water Conservation, Australia, Retrieved form: http://www.dlwc.nsw.gov. au/care/water/groundwater/reports/pdfs/castlereagh_map_notes.pdf.

Sassaman, R.W., 1981. Threshold of concern: A technique for evaluating environmental impact and amenity values. J. Forestry, 79: 84-86.

Secunda, S., M. Collin and A.J. Melloul, 1998. Groundwater vulnerability assessment using a composite model combining DRASTIC with extensive agricultural land use in Israel's Sharon region. J. Environ. Manage., 54: 39-57.

Sener, E., S. Sener and A. Davraz, 2009. Assessment of aquifer vulnerability based on GIS and DRASTIC methods: a case study of the Senirkent-Uluborlu Basin (Isparta, Turkey). Hydrogeol. J., 17: 2023-2035.

Sharma, H.D. and S.P. Lewis, 1994. Waste Containment Systems, Waste Stabilisation, and Landfills. J. Wiley and Sons, Chichester.

Shopley, J.B. and R.F. Fuggle, 1984. A comprehensive review of current EIA methods and techniques. J. Environ. Manage., 18: 25-27.

Singh, S.K., C.K. Singh and S. Mukherjee, 2010. Impact of land-use and land-cover change on groundwater quality in the Lower Shiwalik hills: A remote sensing and GIS based approach. Cent. Eur. J. Geosci., 2(2): 124-131.

Smh, A. and A. Chandra, 2004. Decision support system for environmental impact assessment using fuzzy logic. Proceeding of International Conference on "Energy and Environment-Strategies for Sustainable Development, (ICEE-SSD), N. Delhi, India.

Stull, E.A., M.B. Bain, J.S. Irving, K.E. LaGory and B.W. Witmer, 1987. Methodologies for assessing the cumulative environmental effects of hydroelectric development on fish and wildlife in the Columbia River basin. Recommendations, Argonne National Laboratory, Argonne, Illinois, (1): 75-78, 110-113 and 126-139.

USDA (United State Department of Agriculture), 1994. Permeability Key. Retrieved form: http://www. mn.nrcs.usda.gov/mo10/mo10guides/permkey.

WAJ (Water Authority of Jordan), 1995. Groundwater resources of Northern Jordan Groundwater Abstraction in Northern Jordan. Water Authority of Jordan, Amman, Jordan, Vol. 2, Part 1.

Wagh, C.H. and M.G. Gujar, 2012. The environmental impact assessment by using the Battelle method. Int. J. Sci. Res., 3(7): 82-86.

Zelenakova, M. and L. Zvijakova, 2011. Environmental impact assessment in context of water structures. Proceeding of the 8th International Conference, Environmental Engineering, Vilnius, Lithuania.