Vol. 14(2), pp. 40-48, February 2020
DOI: 10.5897/AJEST2019.2800
Article Number: CFCA4AE62988
ISSN: 1996-0786

http://www.academicjournals.org/AJEST

ACADEMIC JOURNALS
expand your knowledge

African Journal of Environmental Science and Technology

Full Length Research Paper

Application of a decision support tool for municipal solid waste open dumps remediation in Cape Verde

Ailton João Gonçalves Moreira[1*], Juliano Cunha Gomes[2], Joana de Brito Mendonça[3] and Armando Borges De Castilhos Junior[1]

[1]Department of Environmental and Sanitary Engineering, Santa Catarina, Federal University of Santa Catarina, Brazil.
[2]Federal Institute of Santa Catarina, Garopaba Campus, Santa Catarina, Brazil.
[3]National Water and Sanitation Agency - ANAS, Cape Verde.

Received 28 November, 2019; Accepted 24 January, 2020

Open dumps are places where solid waste is disposed directly on the ground, without any environmental assessment, resulting in environmental, societal and economic damages. In Cape Verde, most of the municipalities dispose their solid waste on open dumps. Cape Verde's new policies on solid waste management determined the closure and the remediation of all the dumps around the country. In this context, this research diagnosed the conditions of tree dumps in Santiago Island and one dump in Fogo Island, in order to rank them for remediation priorities. Also, remediation scenarios and actions for each of the dumps were proposed, using Decision Support Tools (DST). Data were collected by visiting the dumps and applying field questionnaires. The results demonstrated a similarity between Santiago's open dumps (Santa Cruz, Santa Catarina and Praia Municipal Dumps), having a "Medium" impact level. São Felipe Municipal Dump located in Fogo Island has the highest impact level and it is the priority for remediation actions. The decision support tool usage proved to be an important instrument to aid decision making for managing areas contaminated by Municipal Solid Waste (MSW) in Cape Verde.

Key words: Open dumps, diagnosis, remediation scenarios.

INTRODUCTION

Municipal Solid Waste (MSW) management is a basic human right. However, the public and political profile of MSW management are lower than other basic services, resulting in several consequences for society and the economy (UNEP, 2015). The storage, collection, transportation, treatment and final disposal of MSW are reported as the major problem in urban centers (Okot-Okumu, 2011; Mgimba and Sanga, 2016). A rapid population growth and urbanization in developing countries have been increased the waste generation (Kurian et al., 2005). Waste management practices in most African countries are characterized by the indiscriminate dumping of refuse in water bodies and on isolated sites, which further exacerbates the low sanitation level in most African countries (Bello et al., 2016). These management practices and poor technology

*Corresponding author. E-mail: ailtonjgmoreira@gmail.com.

applied in the final disposal of MSW are some of the reasons for the existence of open dumps (Hoornweg and Bhada-Tata, 2012). Open dumps are places where the waste is disposed directly on the ground without environmental controls. A typical open dumpsite consists of wastes from many sources, wastes types and compositions. In most cases, the waste deposited is not covered or compacted and it remains susceptible to open burning (Mavropoulos et al., 2016). According to “Waste Atlas: The world’s 50 biggest dumpsites” 2014 report, most of the biggest dumps are located in African countries, Latin America, the Caribbean, and North Asia, where more than two-thirds of the world's population lives (Mavropoulos et al., 2014).

Open dumps can cause serious impacts to the air, soil, surface water and groundwater, as well as social and economic impacts (Danthurebandara et al., 2012). Open dumps' environmental impacts are related to solid waste decay leaching and rainwater percolation. The leaching may contain biological and chemical pollutants that originated from the MSW, becoming a potential surface and groundwater contaminants (Moravia, 2010; Castilhos Junior et al., 2003). Air pollution is resulted from the indiscriminate burning of solid waste or from the anaerobic degradation of the organic fraction of MSW, which produces gases as methane (50- 75% of the composition in volume) and carbon dioxide (25- 50% of the composition in volume) (Ezyske and Deng, 2012; FNR, 2010). The methane is lighter than air and it is flammable. Thus, it is important to implement instruments to control the migration of the gases produced on dumpsites, especially where there are constructions near them, as the gases could be accumulated and may cause explosions (Gill et al., 1999). Another environmental impact caused by open dumps is related to soil pollution by different metals. The metals can be transferred to plants by different means (Voutsa et al., 1996). Contaminants can be found in dumps in different manners, depending on their characteristics. Despite that, contaminants almost always end up accumulated on the soil or carried to water bodies.

Open dumps cause social impacts as they become attractive to a low-income population seeking work alternatives by collecting recyclable materials. This activity put people in contact with all types of waste, also, they become susceptible to accidents. The activity hurts human dignity and configures as a public health problem, therefore, attention has been done to these problem resulting from the inhalation of particulate matter emitted at these sites (Castilhos Junior. et al., 2013; Ramos, 2016; Coelho and Sales, 2017; Peter et al., 2018). Thus, waste pickers formalization is necessary in order to improve the efficiency of the services and to comply with safety and health regulations (Okot-okumu, 2012). Beyond the social aspects, open dumps cause devaluation, degradation and unavailability of land in its surroundings because of vectors of disease, smell, smoke, noise and threats to water supply, impacting the local economy (Danthurebandara et al., 2012).

Open dumps can be considered as contaminated and degraded areas caused by improper wastes disposal. According to CETESB (2001), the area is considered contaminated when elements or substances of environmental interest are above the pre-established limits representing a risk to human health and so, immediate action is needed in order to minimize the exposure routes, as well as the restriction of local uses. So, to manage these contaminated areas, two basic principles are necessary. The first one is the identification of the contaminated area aiming to define the region of interest, identification of potentially contaminated areas; preliminary assessment and; confirmatory investigation. The second one is the recovery process of the contaminated area that whose main objective is the adoption of corrective measures in these areas in order to recover them for a use compatible with the established goals to be achieved after the intervention (CETESB, 2001).

Theoretically, the best way to recover the open dumps could be the complete removal of the deposited waste, sending them to sanitary landfills and recovering the area of an open dump with natural soil of the region. However, the cost would be high, thus making the process unfeasible (Monteiro et al., 2001). Therefore, according to (Coelho and Sales, 2017), some simple and economical actions can be done to minimize the problem of open dumps like: terminate its operation, requalifying and reducing the negative environmental impacts suffered by the area and giving them another purpose; transform the open dump into a controlled/sanitary landfill which promote the gradual recovery of the degraded area while maintaining its operation. This second option can be a long-term goal while physical and financial means still limited. If there are a number of dumps that need to be rehabilitated and only limited resources are available, a higher priority may be assigned to dumpsites with high health risk, maximum environmental impacts and public concerns and minimum rehabilitation costs (Joseph et al., 2010).

For effective planning and development of strategies for sustainable management of MSW, information about the quantity and categories of MSW is of great importance (Mgimba and Sanga, 2016). In Africa, the accelerated urban growth since the 1960s has put pressure on land resources within the cities surrounding areas, as well as, the ever-increasing population density has led to MSW generation increment (Fenta, 2017). In sub-Saharan Africa, MSW generation reaches 62 million tons per year. The per capita MSW generation in 2012 around sub-Saharan Africa was from 0.09 to 3.0 kg/cap/day (kilogram per capita day), its average was 0.65 kg/cap/day and it was projected to reach 0.85 kg/cap/day by 2025. These increasements are affected by economic development, industrialization, society's habits, place and climate. In this region, oceanic islands have the highest per capita MSW generation probably because of tourism and more complete accounting of all MSW generated (Hoornweg and Bgada-Tata, 2012). In Cape Verde, an archipelago located in the west and sub-Saharan Africa, the MSW per capita generation was 0.5 kg/cap/day in 2012 and it is estimated an increase to 0.7 kg/cap/day in 2025 (Hoornweg and Bgada-Tata, 2012). With approximately 500 mil inhabitants, the population growth is expected to be around 1.2% per year by 2030, which will increase the MSW generation (INE, 2017).

In Cape Verde, the gravimetric composition of MSW indicates that the waste with the highest percentage by weight is soil (18.6%) followed by biodegradable waste (17.4%), glass (13.2%) and paper/cardboard (10 %), corresponding to more than 59% of the total waste share (Cabo Verde, 2016). According to data from the National Statistics Institute (INE), in Cape Verde, about 77.3% of the population is covered by collection services of waste either by door-to-door or by the garbage truck and approximately 22.6% of the population dispose their waste improperly in the environment. The destination of most of the collected waste is the grounding on dumpsites (INE, 2017). There are 17 dumps, 1 controlled landfill managed by the Municipal Sanitation Divisions, serving the country's 22 municipalities. Additionally, there are 152 identified uncontrolled disposal sites (Cabo Verde, 2016). Since 2015, the Santiago island, which is the most populous island in Cape Verde, has an Intermunicipal Sanitary Landfill managed by a public-private company, for the disposal of MSW from all its municipalities. With that infrastructure, the municipalities will no longer send its MSW to the three main dumps of the island (Praia, Santa Cruz and Santa Catarina dumps), thus enabling the closure of the dumps activities and their proper recovery.

On the other hand, Fogo Island does not have any sanitary landfill. Thus, the major fraction of MSW is sent to São Felipe dump, one of the biggest dumps of Fogo Island. Cape Verde has passed thorough changes in its waste sector. In 2016 it was approved the National Strategic Plan for Waste Prevention and Management (PENGeR) which is the main guiding document for environmental and solid waste management in the country. One of PENGeR's objectives is to improve MSW management by ensuring the closure of 100% of the uncontrolled dumps by 2020, and the closure of 100% of the municipal dumps by 2030. Also, the PENGeR has strategies to ensure that all refuse is landfilled (Cabo Verde, 2016).

To achieve these goals, the first task is to decide if the site should be closed, remediated or rehabilitated. To achieve that, the environmental risks posed by the site must be assessed. These may involve technical investigations and environmental impact assessments which include consultation with the interested and affected parties (Kurian et al., 2005; Joseph et al., 2010). So, decision making and integration of knowledge from many disciplines are required for managing contaminated areas like open dumps (Bardos et al, 2001). The Decision Support Tools (DST) is an instrument that can assist that, as it is a scientific method of computerized systems for decision making (Adamoski, 2010). It can come in the form of a guide or software. The guide is provided by regulators to achieve standardization and replicable approaches to reaching a decision and the software is produced to assist in decision making through intensive computational analysis processes. The major advantages of using a computerized DST is that it provides transparency of the decision process and permits the effects of uncertainty on the decision to be quantitatively addressed (Sullivan, 2002). In general, these DST are based on multicriteria analyses that use a set of techniques whose purpose is to order or hierarchize the various options that are sometimes conflicting, helping in decision making (Dodgson et al., 2009). As examples of DST, Kurian et al. (2005) proposed the Integrated Risk Based Approach (IRBA) that provides higher priority to dumpsites with high health risk, maximum environmental impacts, minimum rehabilitation costs and sensitive public concerns. Most recent, Gomes (2019) created a DST name Relix to help developing countries in the diagnose and remediation process of their dumpsites, especially Brazil. Therefore, the aim of this research was to identify and diagnose four Cape Verde open dumps as well as to propose remediation scenarios and actions, in order to rank them by their impact level, through a DST, and help managers in the decision making.

MATERIALS AND METHODS

To achieve the goal of this research, field research was carried out to collect the necessary data for the diagnosis of Cape Verde open dumps. The Figure 1 shows the general scheme of the methodology adopted in this research. Below is the description of study area, the description of DST adopted and the procedure to collected date in the field and analyze it.

Study area

In order to estimate the environmental impacts of open dumps as well as to set priorities for their closure and remediation process, three dumps on Santiago Island (Figure 2.) and one on Fogo Island (Figure) were chosen in line with the National Water and Sanitation Agency (ANAS). Thus, the dumps that raise the most concerns in the country were analyzed.

DST chosen

The DST chosen in this research was developed in the Research Laboratory of Solid Waste (LARESO) from the Federal University of Santa Catarina, Brazil. Its purpose is to assist the decision makers in the diagnosis and the remediation of dumps. The tool is named ReLix, and it is free and can be downloaded at the LARESO repository. Its choice was due to the fact that ReLix allows the diagnosis of MSW dumps by applying a field questionnaire and its subsequent analysis in the software. The software generates the most appropriate scenarios and remediation techniques for each

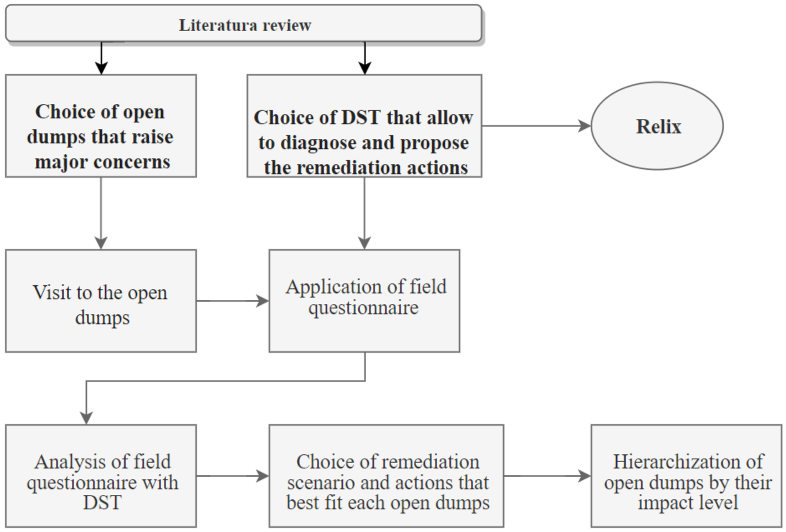

Figure 1. General scheme of the methodology.

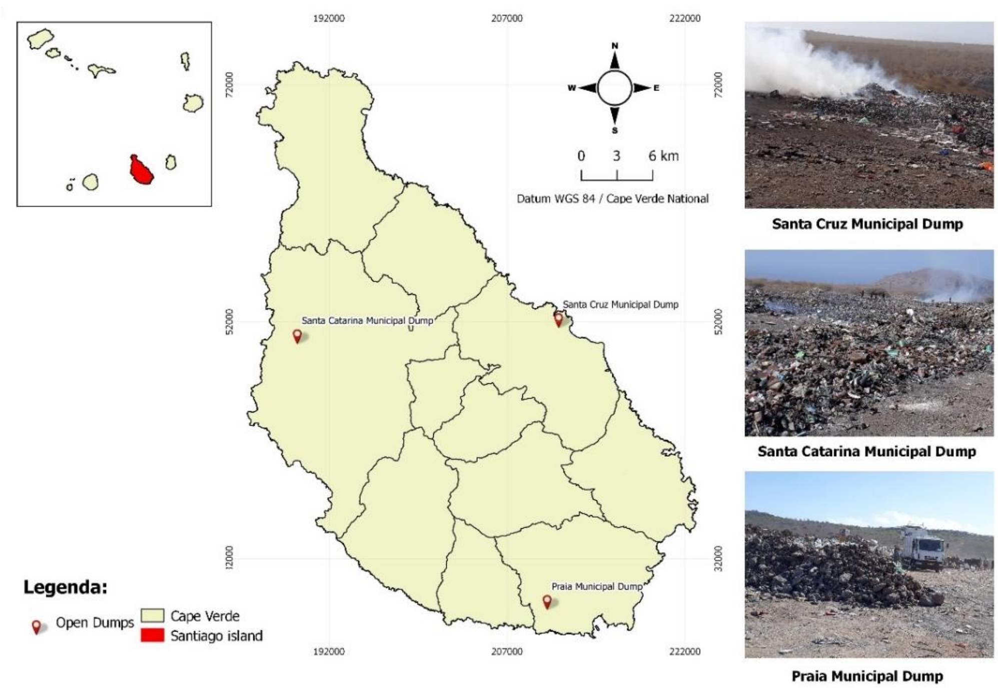

Figure 2. Map of Santiago Island and illustration of dumps situations.

diagnosed dump. The field questionnaire is divided in two parts. In the first part, the area is categorized into one of four possible situations, according to Figure 4.. In the second part, there are sixty-two questions divided into six categories: 1) Characterization of the open dump; 2) Soil and groundwater; 3) Surface water; 4) Social environment; 5) Natural environment and landscapes; 6) Atmospheric (Gomes, 2019).

Beyond the points for each localization situation and for each question of the field questionnaire, the scoring system of the software takes into consideration the qualitative assessment to consider legal aspects and relevant characteristics of the area of the open dump. Altogether there are 3 recovery scenarios, 16 recovery techniques and 34 criteria for choosing the techniques. The tree remediation scenarios possible are: 1) confinement of the waste, 2) conversion to a sanitary landfill and 3) removal of the waste. The remediation techniques for these scenarios generally include cover techniques, direct removal or mining techniques, heat treatment, sanitary landfill installation, area control, groundwater control, collection, treatment of leachate and treatment of gases (Gomes, 2019).

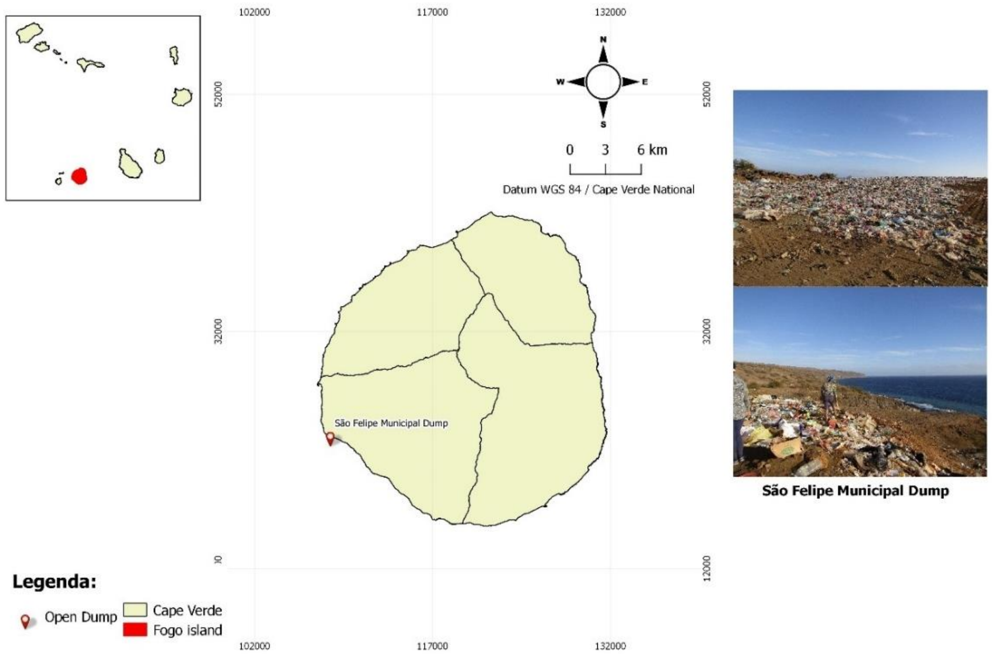

Figure 3. Map of Fogo Island and illustration of dump situation.

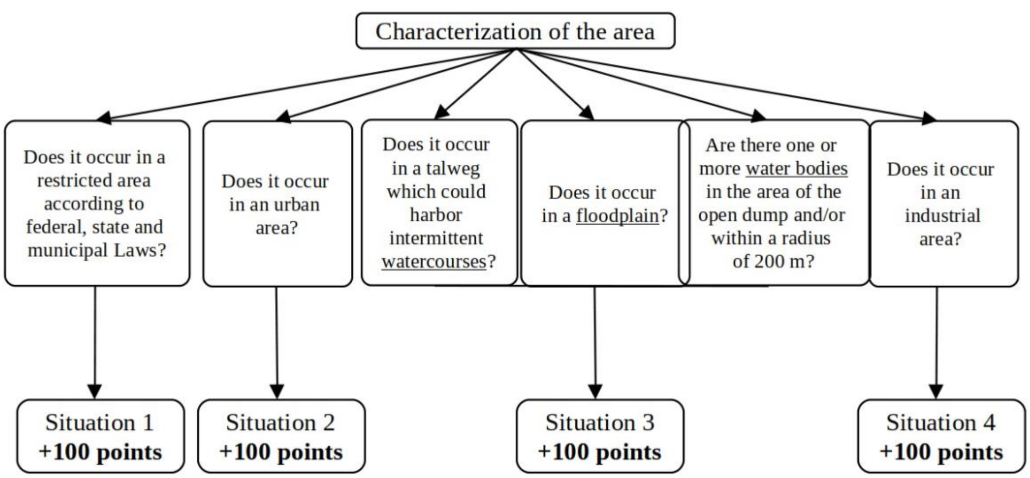

Figure 4. Possible situations of occurrence for an open dump.

The established impact levels by the DST can be seen in Table 1, as well as their scoring ranges. Besides the definition of impact level for the dumps, the Relix also allows to rank the remediation techniques and scenarios by score, which the highest is the most applicable. The score for a remediation technique is obtained according to the number of selection criteria selected in the time of completion of the field questionnaire. It varies from 0 to 5, where 0 indicates that none of these criteria was chosen. Similarly, the remediation scenario score is extracted from the number of selected techniques. After that, the DST awards 6 extra points based on qualitative criteria that consider the legal restriction on the use of the dumpsite, the possibility of the area being used as a landfill for a period exceeding 15 years and the time of operation of open dump (Gomes, 2019).

Visit to open dumps and application of field questionnaire

The visits to the dumps were in January and February 2018, where the field questionnaire was applied. The field questionnaire that comes with DST-Relix was completed by the authors according to visual observation of the open dumps and with the collaboration of the technical manager for the waste sector of each municipality that accompanied the visits. Information that could not be obtained only by the visits to the dumps, was obtained either from these technical managers. After collect the information about each open dump,

Table 1. Impact level established by the DST- ReLix.

Impact level	Score interval	Score range
Reduced	≥ 125 ≤ 160	35
Low	≥161 ≤ 266	105
Medium	≥267 ≤ 479	212
High	≥480 ≤ 832	352

Source: Gomes (2019).

Table 2. Scenario of Remediation and actions proposed for Cape Verde's diagnosed dumps.

Dump	Score /Impact level	Remediation scenario	Remediation actions
São Felipe MD	709/High	Removal of waste	Direct removal of waste to a sanitary landfill Control of the area Passive gas ventilation Groundwater control with extraction wells and subsurface drains with degradable suspension walls or treatment walls
Santa Cruz MD	394/Medium	Confinement of waste	Control of the area Passive gas ventilation Groundwater control with extraction wells and subsurface drains with degradable suspension walls or treatment walls Improvement of existing coverage
Praia MD	379/Medium	Confinement of waste	Control of the area Passive gas ventilation Groundwater control with extraction wells and subsurface drains with degradable suspension walls or treatment walls Improvement of existing coverage
Santa Catarina MD	279/Medium	Removal of waste	Direct removal of waste to a sanitary landfill Control of the area Passive gas ventilation Groundwater control with extraction wells and subsurface drains with degradable suspension walls or treatment walls

Source: Authors.

they were analysed in the DST- Relix and then, the scenarios and remediation actions were proposed, ranked by scores, as mentioned before.

RESULTS

Dumps diagnoses

The diagnoses of dumps with de DST established the impact level of the dumps and proposed remediation sceneries. Table 2 shows the results which allow hierarchizing the dumps by its impact level and assessing the priorities for the remediations actions. The São Felipe Municipal Dump had the highest impact level which means that it is the major priority for the closure process and remediation actions. Its highest score is related to the identification of the four possible situations prosed by DST showed in Figure 4. (Situation 1, 2, 3 and 4). The categories that most contribute to this result are "Characterization of the open dump" (81 scores), "Soil and Groundwater" (65.5 scores) and "Social Environment" (60 scores) (Figure 5).

The Santa Cruz Municipal Dump is in an urban area (Situation 2). It had the major scores on Santiago Island, and it is the major priority for remediation actions on this island. The categories that most contribute to its medium level impact are "Characterization of the open dump"

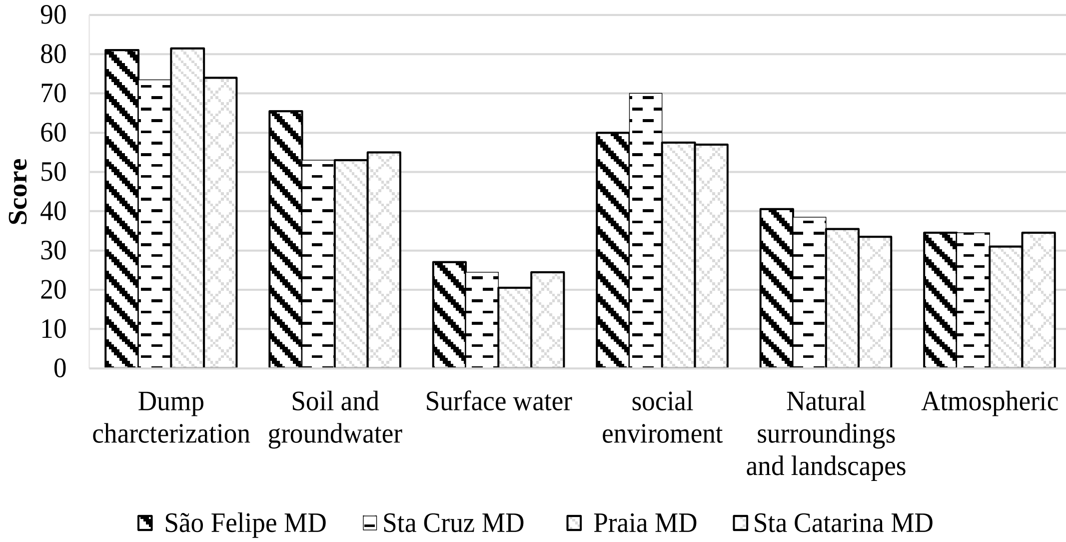

Figure 5. Open dump score by category obtained from DST- Relix.

(81.5 scores), “Social Environment” (57.5 scores) and “Soil and Groundwater” (53 scores) (Figure 5). Lastly, Santa Catarina Municipal Dump has the lowest impact level scores. None of the four possible situations proposed by DST was identified. The three main categories influenced in its medium impact level are “Characterization of the open dump” (74 scores), “Social Environment” (57 scores) and “Soil and Groundwater” (55 scores) (Figure 5).

The same DST was applied in six open dumps in Brazil by Gomes (2019). Five of them had medium impact with scores varying from 320 to 476 and only one had a high impact level with score 538. As obtain in this research, all the open dumps with medium impact had at most two situations identified. Those had high impact level had more than two situations identified. So, the number of situations identified on the field is important to the final score of the dump and its impact level.

Scenario and remediation techniques

All diagnosed open dumps demonstrated the need for remediation. For the São Felipe and Santa Catarina Municipal Dumps, the scenario proposed was “Removal of waste” which will be sent to sanitary landfills as proposed by Monteiro et al. (2001) as an ideal solution. The São Felipe dumps area is inappropriate to implement a landfill for over 15 years and it is located in a place with environmental restriction (near the sea). As recommended by FEAM (2010), to convert open dumps to sanitary landfills, the dimensions and characteristics of the terrain must allow its use for an additional period of 15 years which is not answered by these dumps. As the Fogo island does not have a sanitary landfill yet, it is necessary to implement it in order to receive the wastes from municipalities and after, a fraction of resulting material from open dumps remediation. On another hand, the Santa Catarina Dump does not have any environmental restriction but it does not meet the normative criteria for operating as a landfill for more than 15 years. As the Santa Catarina Dump has been operated for less than 30 years, there may still be a significant gas generation and waste leaching from the site (FNR, 2010; Williams, 2005; MMA, 2019), therefore, the removal of waste is the best option. In this case, the waste should be sent to the Intermunicipal Sanitary Landfill of Santiago island.

For Santa Cruz and Praia Municipal Dumps, the scenario proposed was “Confinement of waste” because both are in places with environmental restriction, they do not meet the normative criteria for operation as a landfill for more than 15 years and its operation exceed 30 years which means that the generation of gas and waste leaching is relatively low. The scenario proposed for these open dumps implicated in the conformation of the final surface of the embankment slopes, as recommended by Alberte et al. (2005), and the maximum isolation of the waste pile.

As showed in Table 2, for each dump it was proposed the remediation actions that best fit the area. The “Control of the area” was suggested for all the diagnosed dumps because it was found in all of them concerns about erosion process. This action is also necessary to avoid the irregular use and occupation of the dump’s areas as there were pickers in all the diagnosed dumps. Therefore, it is necessary not only avoiding access to these areas but also to create mechanisms to insert these people in the waste formal market and give them more safety and protection at work as proposed by Okot-Okumu (2011). To reduce the risks of explosion due to gas accumulation in the waste pile, it was proposed the “Passive gas ventilation”. This choice is mainly due to the fact that quantities of gas emissions are low, so passive gas ventilation can be used to vent the gases into the atmosphere avoiding their accumulation. Besides the low emissions of gases, fire and explosion episodes have been reported in some of the dumps, that may have been caused by biogas accumulation or indiscriminate burning of waste in these dumps.

The other remediation action suggested for all the diagnosed dumps was the “Groundwater control with extraction wells and subsurface drains with degradable suspension walls or treatment walls”. This remediation action is used for groundwater contamination by waste leaching. Studies have shown that near the open dumps, the groundwater quality is worse (Ujile et al., 2012; Usman et al., 2017). Besides that, groundwater monitoring is necessary at all dumps containing a significant amount of wastes (Joseph et al., 2010). So, there is a need to monitor the groundwater quality and safeguard this import resource from Cape Verde.

“Improvement of existing coverage” was one of the suggested remediation actions for Santa Cruz and Praia Municipal Dumps because the country is located in arid climate regions with low rainfall, where waste is partially settled and where construction waste is deposited. The final soil cover (or cap) is applied to a completed disposal facility to act as a barrier in order to reduce de infiltration of water into disposal area, reduce gas migration, prevent burrowing animals from damaging the cover, prevent the emergence of insects/rodents from the compacted refuse, minimize the escape of odors and support vegetation (Joseph et al., 2010). For São Felipe and Santa Catarina Municipal Dumps this technology was not recommended because the proposed scenario was the removal of waste from the area and its transfer to a sanitary landfill. All the scenarios and remediation actions proposed aims to contain or mitigate the contamination in the site, promoting the improvement for future usage of the area.

The diagnose of the open dumps from Cape Verde with Relix was coherent with the diagnose expected by specialists as well as obtained by Gomes (2019) when applied the same DST in the diagnose of six open dumps in Brazil. The DST gave rapid information about the environmental conditions of the open dumps, helping in the decision making about the priorities in the closure and remediation processes. This work has shown that one of the major challenges in many African countries, such as Cape Verde, is the creation of technical means and infrastructure that can support MSW management. As shown by Ventura et al. (2013), improvements in the management of the MSW are necessary for Cape Verde´s municipalities. Thus, it is recommended the implementation of better waste disposal technologies such as sanitary landfills and encourages initiatives to reduce the amount of waste that is sent to final disposal sites. It is also important to avoid sending the organic fraction of the waste to sanitary landfill but to value them through composting or anaerobic digestion. To achieve that, a selective collection should be implemented concurrently with a strong environmental education that encourages waste segregation at the sources and encourages reduction, reuse and recycling of the waste.

Due to the lack of legislation in Cape Verde about contaminated areas as well as the standard procedures for the rehabilitation and recovering of the open dumps, it was used Brazilian’s standards, once the DST used came from that country. So, the legal and regulatory framework that guides the waste sector in Cape Verde should be improved to better manage the MSW in both public and private spheres. The establishment of mechanisms that can assess the quality of the services provided is also necessary, highlighting the need for continuous improvement the environmental conditions.

Conclusion

The ReLix proved to be an important DST, allowing the public manager to diagnose the dumps as well as to choose the priorities for the closure process of the dumps aiming for their subsequent recovery and adjustments. The speed and ease with which results are obtained are two of the major advantages of its usage for managing MSW contaminated areas. The higher score of São Felipe Municipal Dump shows that it is the priority for remediation processes.

As well as presented in this research, other dumps of Cape Verde can be diagnosed with this DST and give an important knowledge of impact level and remediation technologies that can be applied for their remediation process. In order to improve the diagnose, it is necessary more precise information about soil and groundwater contamination, damage to the population residing in the dump and/or surroundings, the health conditions of the population residing in the dump and/or surroundings, damages to animals, recent explosions occurrences and the possibility of gas accumulation and migration. In addition to the need for the aforementioned data, it is important to obtain information about: the amount of MSW arriving the dumps; soil drilling and groundwater analysis and determination of the piezometric level below the waste; tests for the determination of soil permeability; and estimation of leachate and biogas produced. This diagnosis only takes into consideration the environmental and social aspects of open dumps. So, we encourage the evaluation of the economic aspects of all the scenarios and remediation actions proposed in order to make the best decision for each open dump.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Adamoski M (2010). Wast Management System for Western Africa - Analysis of systems successfully applied in the world that may fit the reality faced in Western Africa. UPPSALA Universitet.

Alberte EPV, Carneiro AP, Kan L (2005). Recuperação De Áreas Degradadas Por Disposição De Resíduos Sólidos Urbanos. Diálogos and Ciência 5:15.

Bardos RP, Mariotti C, Marot F, Sullivan T (2001). Framework for Decision Support used in contaminated land management in Europe and North America. NATO/CCMS Pilot Proj Phase III.

Bello IA, Ismail MN bin, Kabbashi NA (2016). Solid Waste Management in Africa: A Review. International Journal of Waste Resources 6(2):4-7.

Bouldry T (2016). A Roadmap for closing Waste Dumpsites. International Solid Waste Association 50(7):109-116.

Cabo Verde (2016). Plano Estratégico Nacional de Prevenção e Gestão de Resíduos em Cabo Verde - PENGeR. Praia, Cabo Verde.

Castilhos Junior AB de, Celina LL, Gomes LP, Pessin N (2003). Alternativas De Disposição De Resíduos Sólidos Urbanos Para Pequenas Comunidades. Rio de Janeiro: ABES, RiMa.

Castilhos Junior AB de, Ramos NF, Alves CM, Forcellini FA, Graciolli OD (2013). Catadores de materiais recicláveis: análise das condições de trabalho e infraestrutura operacional no Sul, Sudeste e Nordeste do Brasil. Ciência and Saúde Coletiva 18(11):3115-3124.

CETESB (2001). Manual de gerenciamento de áreas contaminadas: Projeto CETESB - GTZ Cooperação Técnica Brasil - Alemanha. São Paulo, Brasil. https://cetesb.sp.gov.br/areas-contaminadas/manual-de-gerenciamento-de-areas-contaminadas/.

Coelho GTF, Sales LLS (2017). Recuperação de áreas degradas por disposição de resíudos sólidos urbanos.

Danthurebandara M, Passel S V, Nelen D, Yves T, Acker K Van (2012). Environmental and Socio-Economic impacts of landfills. Linnaeus ECO-TECH 2012. pp. 40-52.

Dodgson JS, Spackman M, Pearman A, Phillips LD (2009). Multi-criteria analysis : a manual. Appraisal 11(1-3):16.

Ezyske CM, Deng Y (2012). Landfill management and remediation practices in New Jersey, United States. in: Kumar, Dr. Sunil (ed.). Management of organic waste. New Jersey, USA: hard cover pp.149-166.

FEAM (2010). Caderno técnico de reabilitação de áreas degradadas por resíduos sólidos urbanos. http://www.feam.br/images/stories/Flavia/areas_degradadas.pdf.

Fenta BA (2017). Waste management in the case of Bahir Dar City near Lake Tana shore in Northwestern Ethiopia: A review. African Journal of Environmental Science and Technology 11(8):393-412.

FNR (2010). Guia Prático do Biogás - Geração e Utilização. Gülzow. 5:233. http://web-resol.org/cartilhas/giz_-_guia_pratico_do_biogas_final.pdf.

Gill MD, Hauser VL, Horin JD, Weand BL, Casagrande DJ (1999). Landfill Remediation Project Manager's Handbook. Mclean, Virginia: Mitretek Systems.

Gomes JC (2019). Desenvolvimento de ferramenta para diagnóstico e recuperação de áreas degradadas por disposição inadequada de resíduos sólidos urbanos. Universidade Federal de Santa Catarina.

Hoornweg D, Bhada-Tata P (2012). What a waste: A global review of Waste Management. Urban Development Series Knowledge papers 15.

INE (2017). Anuário Estatístico Cabo Verde 2016. Praia, Cabo Verde.

Joseph K, Nagendran R, Thanasekaran K, Visvanathan C, Hongland W (2010). Dumpsite reahabilitation manual. Chennai, Índia: Centre for Environmental Studies.

Kurian J, Esakku S, Nagendran R, Visvanathan C (2005). A decision making tool for dumpsite rehabilitation in developing countries. In: Tenth International Waste Management and Landfill Symposium. Sardinia, Italy.

Mavropoulos A, Koller H, Luecke M, Shrestha S, Tanaka M, Themelis N, Juca J, Kalogirou S, PariatambY A, Russo M,Velis C, Goran V (2014). Waste Atlas The World’s 50 Biggest Dumpsites.

Mavropoulos A, Marinherio L, Cohen P, Law J, Greedy D, Loureiro A, Plimakis S, Mgimba C, Sanga A (2016). Municipal Solid Waste Composition Characterization For Sustainable Management Systems In Mbeya City, Tanzania. International Journal of Science, Environment and Technology 5(1):47-58.

Mgimba C, Sanga A (2016). Municipal Solid Waste Composition Characterization For Sustainable Management Systems In Mbeya City, Tanzania. International Journal of Environmental Science and Technology 5(1):47-58.

MMA (2019). Aproveitamento Energético do Biogás de Aterro Sanitário. https://www.mma.gov.br/cidades-sustentaveis/residuos-solidos/politica-nacional-de-residuos-solidos/aproveitamento-energetico-do-biogas-de-aterro-sanitario?tmpl=component&print=1.

Monteiro JHP, Figueiredo CEM, Magalhães AF, Melo MAF de, Brito JCX de, Almeida TPF de, Mansur GL (2001). Manual de Gerenciamento de Resíduos Sólidos. Rio de Janeiro: IBAM.

Moravia WG (2010). Avaliação do tratamento de lixiviado de aterro sanitário através de processo oxidativo avançado conjugado com sistema de separação por membranas. Universidade Federal de Minas Gerais.

Okot-okumu J (2012). Solid Waste Management in African Cities – East Africa. Creat Commons 57-72:3-20.

Peter AE, Shiva Nagendra SM, Nambi IM (2018). Comprehensive analysis of inhalable toxic particulate emissions from an old municipal solid waste dumpsite and neighborhood health risks. Atmospheric Pollution Research 9(6):1021-1031.

Ramos NF (2016). Proposição de metodologia para Apoio à Decisão para a recuperação de área degradada por disposição irregular de resíduos sólidos urbanos. Universidade Federal de Santa Catarina.

Sullivan T (2002). Evaluating Environmental Decision Support Tools. Upton, NY 11973.

Ujile AA, Omo-Irabor OO, Ogbonna J (2012). Groundwater contamination at waste disposal sites at Ibadan, Nigeria. The Journal of Solid Waste Technology and Management 38(3):149-56.

UNEP (2015). Global Waste Management Outlook. http://wedocs.unep.org/bitstream/handle/20.500.11822/9672/-Global_Waste_Management_Outlook-2015Global_Waste_Management_Outlook.pdf.pdf?sequence=3&isAllowed=y.

Usman M, Yasin H, Nasir DA, Mehmood W (2017). A case study of groundwater contamination due to open dumping of municipal solid waste in Faisalabad, Pakistan. Earth Sci Pakistan 1(2):15-16.

Ventura JE, Santos EDOS, Cabral A (2013). A Problemática Dos Resíduos Sólidos Na Cidade Da Praia. In: Atas do Colóquio Internacional Cabo Verde Guiné-Bissau: Percursos do saber e da ciência.

Voutsa D, Grimanis A, Samara C (1996). Trace elements in vegetables grown in an industrial area in relation to soil and air particulate matter. Environmental Pollution 94(3):325-335.

Williams PT (2005). Waste Treatment and Disposal. Environmental Engineering. Chichester, UK: John Wiley & Sons Ltd 2:380.