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Dealing with the Green Crisis: Understanding and Mitigating Iraq's Environmental Challenges

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Abstract: Building an economy in Iraq is really important to sustain the resources of this country down the road. Solid waste is a big issue, which referred to the refuse materials that resulted from peoples' activities with various compositions. Although it is a waste officially, really, it is wasted resources that have a lot of economic potential if used in the right way. At a global scale, waste generation amounted to 2.02 billion tons in 2016 and is estimated to soar to 3.4 billion tons by the year of 2050 due to drivers such as population growth and rapid urbanization. There are major issues facing Iraq especially in relation to solid waste, this is worsened by the fast growing population, failing infrastructure after decades of conflict and poor legislation with limited public understanding. Multiple alternatives of optimal solutions are proposed as indicated and validated by the studies. It suggests methods such as building infrastructure via investment in state-of-the-art sanitary landfills along with recycling facilities and waste-to-energy facilities. Studies also underlie the need for enhancing policy provisions, raising public awareness through vigorous campaign, and involving all stakeholders. The research underscores the need to incorporate up-to-date technologies, e.g. GIS in the management and site selection of landfill in urban planning processes for more informed decision making. These programs are part of a larger effort to convert waste from an ecological liability into an asset – and thus to establish a more sustainable future.

Key words: Solid Waste Management, Recycling, Waste Classification.

1. Introduction

In the context of worsening environmental and economic challenges, creating a sustainable economy is imperative to sustain resources for future generations **(Rashmi *et al.*, 2022).** Solid waste is one of its visible examples, creating a tangled mess for which there are no simple answers. This type of

waste is termed as waste which consists of lefted-over solid materials generated by human and society for special treatment because of differences in composition and classification **(Jiang *et al.*, 2025).**

Although solid waste has long been looked upon as such, a perspective in which it is seen as a wasted resource that presents great economic opportunities provides the new paradigms with notable financial benefits. It has been a problem of an alarming nature in terms of global statistics which showed that production of solid waste increased to 2.02 billion tons during 2016 and is expected to rise by 70% up to reach 3.4 billion tons by the year 2050 **(Menon & Dubey,2024).** Several factors account for this increase, including the rapid rate of population and urbanization growth, management challenges (weak planning and lack of coordination in both public authorities and private sector firms) as described by **AL-MOHAMMED *et al.* (2021)**. This reality emphasises the pressing importance of comprehensive waste management and minimization measures, and regulatory framework which can convert the burden of waste as an environmental liability into an economical asset.Solid waste accumulation and power shortage represent a world issue, Iraq has an increasing solid waste management problem that have kept over the years without sustainable solution **(Hasan & Abbas, 2025)**.

2. Problem Statement and the Main

lays down the research plan to explore the existing situation for SW and HW management in Iraq, highlighting administrative and environmental challenges, international/local best practices and proposing tangible and sustainable recommendations.

3. Theoretical Background and Literature Review

The study's objective **(AL-MOHAMMED 2021)** was to assess and improve SWM in Iraq. A total of 326 people joined in the study, and interviews and questionnaires were used to obtain information. The study findings showed major barriers such as the small role of municipalities and no fixed schedule for waste pick-up, not sorting at source or coordination between the residents and municipality. The results also revealed that there are no sanitary landfills in most of the municipalities, and the legislation related to waste management system was not enough. In the light of such findings, it is suggested in this study that waste sorting and recycling stations be formed, the private sector be more involved and obstacles encountered by the municipality are overcame as well as community awareness through educational seminars to increase.

Jbara (2024) discussed the solidWaste management problem in Diyala Governorate, Iraq. The investigation found that the absence of a comprehensive approach to waste management leads to air, soil and water pollution with heavy metals and contributes significantly to risks for public health. The high to low record of pollution in the study covered five landfill sites, with the worst level experienced at Kanaan and the lowest at Hamrin, according to the research. Based on its findings, the study recommends more stringently strategies for waste management such as sorting and recycling in order to alleviate these negative effects on environment and public health.

A study by **Nawir *et al.* (2025)** considered the possibility of power generation form solid waste in Babylon City for2003 and 2030. The energy potential was estimated in the study by using different technologies, such as incineration, gasification and anaerobic digestion. It was found that with an increase in the local population, more waste is generated and incineration is the most efficient technology for gaining greater electricity generation compared to other conversion technologies.

Classification of wastes

Types of waste streams are generally divided into two categories – organic and inorganic; a distinction based on their chemical structure and biodegradability. This differentiation is of high relevance to effective waste management because both types of the wastes have special environmental imperatives and they are likely to be source of pollutions, either discrete (Menon and Dubey, 2024 Japgolly Figure) or non-point sources as displayed in figure. **(Menon and Dubey, 2024).**

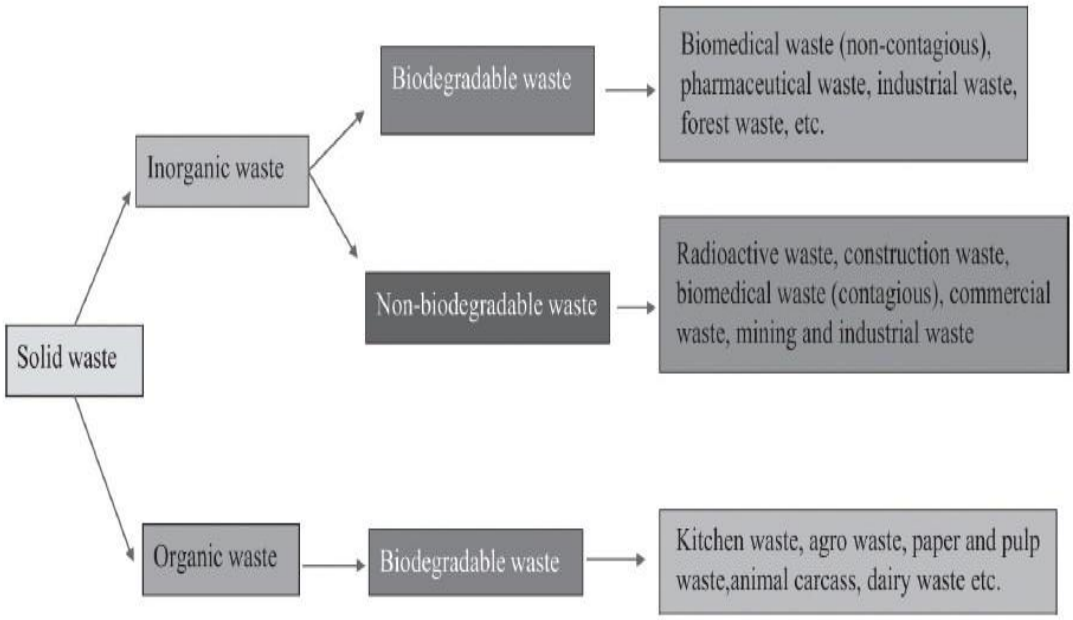

Figure: Classification of wastes (Menon and Dubey, 2024).

Solid Waste Management Challenges and Solutions in Iraq

In various aspects Iraq SWM system has several structural handicaps and limited infrastructure, weak regulations implementation, poor public participation **(Kareem *et al.*, 2024).** This crisis is further compounded by heritage factors such as political instability and conflict spanning over the decades that have left the entire infrastructure highly neglected, in addition to emergent ones including rapid urbanisation and population increase **(Das *et al.*, 2019; Hemidat *et al.*, 2022; Aziz *et al.*, 2011).** This has resulted in increased waste quantities and stress on the available systems, leading to ineffective collection services, widespread informal dumping and considerable environmental pollution and public health risks.

In order to move toward sustainable waste management, literature suggests that the integrated approach focusing on some domains is needed. This includes investment into modern sanitary landfills, recycling plants, waste-to-energy projects and infrastructure. The study also emphasizes the needs for legislation, stirring public enlightenment through aggressive campaigns and bringing on board all partners in both formal and informal sector to end this practice **(Kareem *et al.*, 2024).** In addition, the findings of some studies stress on technology application, such as Geographic Information Systems (GIS), in urban planning and optimal site selection of landfills to guarantee that they are grounded in scientific and sustainable principles **(Manguri *et al.*, 2024).**

Problems and Obstacles of Recycling in Iraq

Iraq is confronted with a number of challenges which are, predominantly: the post- effects of the recent wars, financial limitations that restrict adequate levels in energy provision and growth population **(Anssari *et al.*, 2020).**

In order to fix these problems, upgrade of the energy infrastructure is viewed as one of the vital factors. Elsewhere, some establishments are adopting a recycling program in which the waste is separated and sold to industries for safe reuse **(Elagroudy *et al.*, 2011).** Problematically, this system is difficult to implement in the case of waste disposal sites, which are generally unsanitary and recycling is not common due to the scant availability of facilities that would allow for its implementation; in other

words, this system does not alleviate solid waste management through all mechanisms in place in Iraq **(Aziz *et al.*, 2011).**

Siting for municipal solid waste (MSW) landfills is an important element in the urban sustainable development, which has great effects on environment, economy and public health of community. The problems of how to dispose of trash safely in a sanitary environment are becoming clear, from the unmanaged growing scale of urban development. As such, the choice of a sanitary landfill site is not a one-off environmental decision but an investment for the future that helps to guarantee clean and sustainable cities. **(Karabulut *et al.*, 2022).**

Classification of landfill

Landfill and landfilling Landfills and the process involved in their construction are engineered facilities which accept the final disposal of solid waste from a variety of domestic, commercial, and industrial sources. This process is based on orderly flow of waste by means of a series of sequential operations. Such measures include monitoring of waste stream on a continuous basis, organized dump and compaction of rejects, and development of extensive environmental surveillance system for the landfill site as well as its surroundings **(Dagwar and Dutta, 2024).** Landfill site selection 1538 The problem of siting is getting more severe in developing countries due to an increase in prices associated with land use, as in the case of Iraq. This sector is confronted with numerous constraints, such as financial, technical and institutional weaknesses, and lacking manpower. All these factors together make it difficult for high standards of landfills to be established and operated at the technical levels **(Sati, 2014).**

Sustainable Waste Management: The Role of Composting and Energy Recovery

Organic waste is one of the sources that can serve as a cheap and clean biofuel from household, commercial and industrial sectors (Menon & Dubey, 2024). Composting is an environmentally sustainable process for converting such waste into a saleable agricultural fertilizer at lower cost compared to landfilling and incineration **(Lesher, 2014).**

Composting has substantial environmental benefits, in addition to the economic ones **(Antler *et al.*, 2022).** It is a water quality treatment technology because it physically filters contaminants from the water flowing across its surface, preventing them from entering into storm drainage and eventually discharging to the Wash **(EPA, 2017).** The energy released as the composting takes place can also be reclaimed and reused for other energy purposes **(Menon and Dubey, 2024).**

Historically, high-content organic waste was used as a fuel source in the United States during the 1970s, accounting for 13% to 20% of the coal used for electricity generation in the country. Furthermore, compost has been utilized in highway construction projects, lawn covering, soil manufacturing, and erosion control **(Lesher, 2014).** To ensure high-quality compost, it is crucial to sort municipal solid waste beforehand to remove non-biodegradable materials, such as plastics and glass **(Menon and Dubey, 2024).**

Case studies:

Nigeria is home to 162 million people and has an annual urban growth rate of 3.78%. Waste production is 0.49 kg per person per day on average. 3 Global waste production is rising, in part because of faster rates of production and consumption. 4 Nigeria produces more rubbish than both the environment and the municipal waste management authorities can handle. Inadequate urban planning makes it more difficult for the municipal waste management authority to operate., Urbanization, poorly designed policies, and a lack of resources to deliver the services that will result in an efficient waste management system. 5, 6, 7, 8, and 9 This has encouraged the growth of open-air landfills that pose a bigger threat to the environment, public health, and quality of life. **(Oguntoyinbo, 2012).**

Table (1). Compares data collected from many studies and articles for the followingcountries: Iran, Iraq, South Africa, India, Nigeria, Pakistan, Gaza Strip-Palestineand Lebanon. The methodology for each case study is summarised in Table 1 (Al-Momani, 2019).

	Location	Aim	Method	Result	Conclusion
Tabrizi *et al.* (2018)	Iran	The purpose of this study was to raise the bar for medical waste management in Iranian community health centers.	Interviews with garbage workers, observations, document checks, clinical audits, and interventional research were carried out.	Following the interventions, medical waste management standards increased by thirty percent. The areas that showed the biggest increases were management and education.	The procedures for managing medical waste were enhanced.
Ali and Jasim (2018)	Baghdad, Iraq	The objective was to investigate the medical waste creation rate in two Iraqi hospitals.	Monthly medical solid waste weights were used to gather data from two hospitals over a three-year period. The average generation rate was then determined. Additionally, disposal techniques related to the generation rate were gathered.	While the number of beds in both hospitals was about equal, the average generation rates were computed and revealed differing values in the two hospitals.	The production of medical solid waste varies. The disparity occurred due of the number of patients who admits the hospitals because of numerous issues concerning the present the status of the country such as an explosion and the economic position
Adekunle *et al.* (2018)	KwaZulu-Natal, South Africa	To evaluate district hospital employees' healthcare waste management knowledge, attitudes, and behaviors	a questionnaire-based observational study. The Statistical Package for the Social Sciences was used to analyze the data.	Healthcare waste management was not well understood (42.7% had poor understanding and 53.9% had good practices).	Healthcare waste management was not well understood (42.7% had poor understanding and 53.9% had good practices).
Alam *et al.* (2019)	Aligarh, India	To evaluate medical waste management in a few Aligarh hospitals	The degree of each material's hazardousness was used to classify medical waste and determine how each material should be disposed.	Due to the use of disposable devices and packing materials rather than reusable ones, medical waste was substantial.	There is no waste management system in hospitals. Most hospitals lacked adequate storage facilities and did not separate or treat the trash before disposing of it. There were fewer employees in charge of rubbish collection and disposal, and their expertise was inadequate.

Anozie *et al.* (2017)	Nigeria	To assess the roles and perspectives of healthcare managers regarding occupational safety and medical waste management	Fifty-four hospital administrators received a questionnaire.	Forty percent of hospital administrators have received training on workplace safety and medical waste management. However, just 1.9% used standard operating procedures.	Both normal medical waste disposal methods and occupational safety training were lacking. In addition to ongoing oversight and control of healthcare operations, appropriate training is required to raise awareness of this issue.
Ali *et al.* (2016)	Pakistan	To ascertain the waste management procedures in a few Gujranwala hospitals	Hospital garbage was weighed over a seven-day period and compared to industry norms. In accordance with hospital waste management regulations, a standard questionnaire was created.	The infectious hospital waste generation rates were nearly 2.924 times higher than the weighted average waste generation rates. The hospitals produced roughly 85 times more general garbage and 30 times more hazardous waste than sharp waste.	Waste generation rates were comparatively greater in small, private, and specialty hospitals. Due to a lack of knowledge about hospital waste management regulations, all 12 of the hospitals surveyed had poor waste segregation, storage, and transportation procedures. Hospital waste management regulations must be properly adhered to.
Caniato *et al.* (2016)	Gaza	To evaluate the handling of medical waste in an emergency	Examining laws, regulations, trash production, visits, interviews, and treatment system assessments	Hospitals produced 683 kg of medical waste every day, compared to 3357 kg. Medical waste was rarely treated, hazardous and non-hazardous trash were only partially separated, and 75% of hazardous waste remained untreated.	A novel approach was put out that might result in more efficient utilization of resources in an emergency.
Maamari *et al.* (2015)	Lebanon	To examine Lebanon's medical waste generation rate	gathering information and amounts produced during a five-year period for fifty-seven hospitals	The rate of trash generation decreases with hospital size.	Hospital beds and the generation rate were shown to be weakly correlated. The number of beds and the production of infectious healthcare waste were found to be strongly correlated.

4. Conclusion

MSWM in Iraq has many difficulties related to the shortcomings of legislation and information, coupled with poor infrastructure for waste disposal. The recommendations further call for enactment of transparent laws favoring waste management and encouraging investment in this area, along with enhancing collection, transportation and treatment activities. The administration must educate the matrix of society on importance of recycling and waste management besides devising a plan to infuse contemporary technology for time saving. Preventing waste management also will be necessary for sustainable development and environmental quality in the country.

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التعامل مع الأزمة الخضراء: فهم التحديات البيئية في العراق والتخفيف من آثارها (مقالة مرجعية)

بشرى زيدان خليل اغا ـ فاطمة مؤيد سامي ـ مها محمد طه النعيمي

الملخص

يُعدّ بناء اقتصادٍ مستدام في العراق أمرًا بالغ الأهمية لضمان استدامة موارد البلاد على المدى البعيد. وتُعدّ النفايات الصلبة من أبرز التحديات البيئية، إذ يُقصد بها المواد الملوثة الناتجة عن الأنشطة البشرية بمختلف تراكيبها. وعلى الرغم من تصنيفها رسميًا كنفايات، فإنها في الواقع تمثل موارد مهدرة تنطوي على إمكانات اقتصادية كبيرة إذا ما أُديرت واستُثمرت بالأساليب المناسبة. وعلى الصعيد العالمي، بلغ حجم توليد النفايات نحو ٢,٠٢ مليار طن في عام ٢٠١٦، ومن المتوقع أن يرتفع إلى ٣,٤ مليار طن بحلول عام ٢٠٥٠، نتيجة لعوامل عدة من أبرزها النمو السكاني المتسارع والتوسع الحضري السريع.يواجه العراق تحديات جسيمة في مجال إدارة النفايات الصلبة، وتتفاقم هذه التحديات بفعل الزيادة المستمرة في عدد السكان، وتدهور البنية التحتية نتيجة عقود من النزاعات، فضلًا عن ضعف الأطر التشريعية ومحدودية الوعي المجتمعي بالقضايا البيئية.وقد اقترحت الدراسات العلمية مجموعة من البدائل التي تمثل حلولًا مثلى لمعالجة هذه المشاكل، حيث أوصت بتطوير البنية التحتية من خلال الاستثمار في مطامر صحية حديثة، إلى جانب إنشاء مرافق لإعادة التدوير ومحطات لتحويل النفايات إلى طاقة. كما أكدت هذه الدراسات على ضرورة تعزيز السياسات والتشريعات البيئية، ورفع مستوى الوعي العام عبر حملات توعوية فاعلة، بالإضافة إلى إشراك جميع أصحاب المصلحة في تطبيق منظومة الإدارة المتكاملة للنفايات. وتُبرز البحوث كذلك أهمية توظيف التقنيات الحديثة، مثل نظم المعلومات الجغرافية(GIS) ، في إدارة النفايات واختيار مواقع المطامر ضمن عمليات التخطيط الحضري، بما يسهم في دعم اتخاذ قرارات أكثر دقة وكفاءة. وتندرج هذه البرامج ضمن إطار جهدٍ استراتيجي شامل يهدف إلى تحويل النفايات من عبءٍ بيئي إلى مورد ذي قيمة اقتصادية، وبما يسهم في تحقيق مستقبل أكثر استدامة للعراق.