مؤسسة الكويت للتقدم العلمي
Kuwait Foundation for the Advancement of Sciences

النفايات الصلبة في دولة الكويت

الدور المقترح لمؤسسة الكويت للتقدم العلمي للتصدي للتحديات

Solid Waste in Kuwait

Proposed Role of KFAS in Addressing the Challenges

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ملخص تنفيذي

تعتبر مشكلة النفايات الصلبة مصدر قلق متزايد في دولة الكويت ودول المنطقة. وقد طلب مجلس إدارة مؤسسة الكويت للتقدم العلمي في اجتماعه بتاريخ 2018/10/17 من إدارة المؤسسة إجراء دراسة لتحديد حجم المشكلة الحالي والتحديات المستقبلية ومدى كفاية الجهود والمشاريع القائمة والمخطط لها لمعالجتها بغرض وضع تصور للدور الذي يمكن أن تلعبه المؤسسة في مواجهة التحديات المتعلقة بالنفايات الصلبة في البلاد بهدف الإسهام في تطوير حلول مناسبة لهذه المشكلة. وقد تم إعداد هذه الدراسة استجابة لهذا الطلب.

تبين من خلال الدراسة أن النفايات الصلبة المتولدة في البلاد تتزايد كمياتها سنوياً بشكل مضطرد، وتقدر الكميات حالياً بحوالي 12 مليون طن سنوياً. وتصنف هذه النفايات حسب الوزن من مخلفات وأنقاض البناء (ما يزيد عن 80٪)، أما الـ 20% المتبقية فهي في الغالب نفايات منزلية وإطارات مستهلكة. وتجدر الإشارة هنا إلى أنه عند تصنيف النفايات الصلبة حسب الحجم فان النفايات الصلبة المنزلية تأتي بالمرتبة الاولى، وتتكون من مزيج معقد من العديد من المكونات كالنفايات العضوية (مواد غذائية)، النفايات الورقية او الكرتونية، معادن، نفايات صلبة بلاستيكية، نفايات صلبة زراعية، حمأة (ناتجة عن معالجة مياه الصرف الصحي)، نفايات صلبة إلكترونية، وغيرها. وتقوم بلدية الكويت حالياً بالتخلص من معظم النفايات الصلبة في مواقع مخصصة كمرادم للنفايات موزعة على 20 موقع في الكويت تبلغ مساحتها الإجمالية حوالي 30 كم^2، علما بأن 12 موقعاً مغلقاً حالياً. ومن إجمالي هذه المواقع، تم تخصيص ستة مواقع لنفايات الأسبستوس وبقايا حظائر الماشية والنفايات السائلة الصناعية، وثلاثة منها مخصصة لمخلفات وأنقاض البناء، والمواقع الباقية عبارة عن مواقع مختلطة للنفايات المنزلية ومخلفات وأنقاض البناء. وتقع معظم هذه المواقع إما قريبة من المناطق السكنية الحالية أو من المناطق السكنية المخطط إنشائها في المستقبل نتيجة للتوسع الحضري. والطريقة الحالية للتخلص من النفايات لها تأثير سلبي على أكثر من صعيد، من حيث تدهور الأراضي، والمخاطر الصحية، والتلوث البيئي، ومن المنظور الاجتماعي والاقتصادي.

بالإضافة إلى الفئتين الرئيسيتين من النفايات الصلبة التي يتم التخلص منها في المرادم (النفايات المنزلية والمخلفات الإنشائية)، هناك أنواع أخرى عديدة من النفايات الصلبة الأكثر تخصصاً والتي تضيف مجتمعة نسبة صغيرة من إجمالي النفايات الصلبة في البلاد. وتشمل هذه النفايات التربة الملوثة بالنفط، ونفايات الطين المستخدم لحفر آبار النفط، وبقايا غسل الرمال من محاجر الرمال، والمواد المشعة، والنفايات الصلبة الصناعية الخطرة الناتجة عن صناعات مختلفة، مثل المواد الحفازة المستهلكة من صناعات التكرير والبتروكيماويات، والرماد المتطاير من محطات توليد الطاقة الكهربائية، والنفايات العسكرية، وغيرها. إلا أن مسؤولية التعامل مع هذه النفايات والتخلص الآمن منها تم إلزامه على الجهات التي تولد هذه المخلفات وذلك بناءً على لوائح الهيئة العامة للبيئة في الكويت (KEPA) والهيئة العامة للصناعة (PIA). وبالتالي، تم استبعادها من هذه الدراسة على الرغم من أنها قد تشكل تهديداً بيئياً خطيراً، خاصةً وأن بعض الكميات قد تنتهي في المرادم أو مواقع تخلص غير مسجلة.

تتم معالجة مشكلة معالجة النفايات الصلبة في البلاد حالياً من قبل عدد من الجهات الحكومية، حيث تلعب الهيئة العامة للبيئة الدور الرئيسي كهيئة إشرافية رقابية، وبلدية الكويت كهيئة التنفيذ الرئيسية المسئولة عن جمع النفايات الصلبة المنزلية والتجارية وإدارة المرادم. ويتم جمع النفايات الصلبة من خلال التعاقد مع شركات خاصة. أما مخلفات البناء والأنقاض فيتم التعامل مع معظمها من قبل مقاولي البناء والهدم، الذين يقومون بجمع النفايات ونقلها إلى المكبات التي تحددها بلدية الكويت. وقد شرعت كل من الهيئة العامة للبيئة وبلدية الكويت منذ سنوات قليلة العمل على معالجة المشكلة بطريقة حديثة وسليمة علمياً، وتقوم كلتا الجهتين حالياً بإجراء دراسات للتأكد من كميات النفايات الصلبة ومكوناتها وتطوير رؤية إستراتيجية لتوفير حلول عصرية.

فقد تعاقدت الهيئة العامة للبيئة مع معهد فراونهوفر أنزيخت (Fraunhofer UNSICHT Institute Branch Sulzbach-Rosenberg)، وهو أحد المعاهد البحثية التخصصية لمجموعة فراونهوفر الألمانية، لإجراء دراسة مفصلة لمشكلة النفايات الصلبة في الكويت. والمعهد متخصص في تطوير عمليات ومصانع تحويل المخلفات العضوية إلى منتجات قيمة وإعادة تدوير المواد المركبة وتطوير مفاهيم إدارة النفايات للبلديات والدول. وقد بدأ المشروع في يناير 2017 لمدة 4 سنوات وسيتناول القضايا الأربع التالية:

1. جرد وجمع البيانات الأولية حول النفايات في الدولة
2. القيام بكشف على المرادم والمكبات في البلاد
3. إنشاء قاعدة بيانات تفاعلية على شبكة الإنترنت تُظهر النفايات ومكبات النفايات
4. إعداد خطة وطنية لإدارة النفايات وخريطة طريق لتنفيذها

والمشروع قيد التنفيذ حالياً وقد تم وضع نظام المعلومات على شبكة الإنترنت تحت مسمى (eMISK) ويشمل العديد من المعلومات البيئية، بما في ذلك معلومات حول النفايات الصلبة، والموقع متاح للجمهور. ويحتوي موقع eMISK على بيانات تغطي عدداً من السنوات. علاوة على ذلك، تعمل الهيئة العامة للبيئة أيضاً على وضع إستراتيجية للتعامل مع النفايات الصلبة من المتوقع أن تكون جاهزة في عام 2021.

وانطلاقاً من دورها المحوري في نشاطات جمع ومعالجة النفايات الصلبة وفقاً للوائح الهيئة العامة للبيئة، فقد بدأت بلدية الكويت في مايو 2018 مشروعاً حيوياً مع البنك الدولي بعنوان "مشروع تخطيط إدارة النفايات التابع لبلدية الكويت" بهدف معالجة ثلاث قضايا رئيسية هي:

1. تقديم الدعم بشأن تخطيط النفايات البلدية وإدخالها في الإستراتيجية الوطنية للنفايات
2. توفير الدعم في تطوير إستراتيجية إشراك المجتمع في إدارة النفايات
3. دعم تطوير نظام معلومات آلية للنفايات

وقد شكلت بلدية الكويت مؤخراً مجموعة عمل لدعم المشروع المذكور أعلاه. وتضم مجموعة العمل ممثلين من البلدية، والهيئة العامة للبيئة، ومعهد الكويت للأبحاث العلمية، وجامعة الكويت، والأمانة العامة للمجلس الأعلى للتخطيط والتنمية، ووزارة المالية، ووزارة التعليم، ووزارة الإعلام.

ومن ناحية أخرى أظهرت دراسة التي يتضمنها هذا التقرير أن كلاً من معهد الكويت للأبحاث العلمية، وجامعة الكويت قاما بإجراء العديد من الأبحاث المتعلقة بمشاكل النفايات الصلبة عالجت عدة جوانب علمية وفنية لهذه القضية. وقد تم حصر ما يزيد عن 65 ورقة بحثية منشورة خلال الفترة من 1990 حتى الآن. كما قامت مؤسسة الكويت للتقدم العلمي أيضاً بتمويل عدداً من المشاريع البحثية المتعلقة بالموضوع لكل من معهد الكويت للأبحاث العلمية وجامعة الكويت والجهات الرسمية الأخرى ذات العلاقة. ومن بين هذه الدراسات دراسة تقدم بها البنك الصناعي الكويتي وتم الانتهاء منها في عام 2010 وتم تمويلها من قبل مؤسسة الكويت للتقدم العلمي ووزارة المالية ونفذت بواسطة البنك الدولي. وتناولت الدراسة ثلاث قضايا رئيسية هي:

1. تقييم وضع قطاع النفايات الصلبة الحالية (عام 2009-2010)
2. تقييم الفرص الاستثمارية لإعادة تدوير النفايات
3. مشاركة القطاع الخاص وآليات الحوافز

كما تبين من الدراسة أن صناعة إعادة تدوير النفايات شهدت نمواً ملحوظاً في دولة الكويت خلال العقدين الماضيين. فلدى وزارة التجارة والصناعة قائمة من 33 شركة مسجلة كمؤسسات لمعالجة وإعادة تدوير النفايات الصلبة، إلا أنه يبدو أن معظم هذه الشركات ليس لديها منشآت لإعادة التدوير. وبالتالي، ربما تكون إما غير نشطة أو فقط تعمل في مجال التجارة بالنفايات الصلبة. ولدى الهيئة العامة للبيئة أيضاً قائمة تضم 26 شركة تعمل في مجال جمع النفايات أو وإعادة تدويرها أو تصديرها ولدى البعض من هذه الشركات مرافق صناعية ذات طاقة إنتاجية محدودة لتدوير بعض أنواع النفايات. إلا أن هناك نقص في المعلومات المتعلقة بأداء هذه الشركات ومستوى مساهمتها في التخلص من النفايات الصلبة في البلاد. وتجدر الإشارة إلى أن هذه الصناعات لا تتلقى دعماً من الحكومة.

ومن خلال دراسة وتحليل المعلومات التي تم الحصول عليها، فقد تم تحديد عدد من الفجوات العلمية والفنية التي تغطي جوانب مختلفة متعلقة بمشكلة النفايات الصلبة. والفجوة الرئيسية هي الافتقار إلى فلسفة واضحة لإدارة النفايات قائمة على المقارنة والاستفادة من تجارب وأداء دول أخرى متقدمة في معالجة مشكلة النفايات. وتشمل الفجوات الأخرى عدم توفر معلومات دقيقة حول مكونات النفايات الصلبة، والآثار الاجتماعية والاقتصادية للمشكلة، ووعي المجتمع حول المشكلة، وبعض تكنولوجيات إعادة التدوير التي قد تحتاج إلى تكييفها مع الظروف المحلية، وبعض القضايا التشريعية والقانونية. وبناءً على نتائج هذه الدراسة، يبدو أن الهيئة العامة للبيئة وبلدية الكويت، من خلال المشاريع والدراسات التي يتم إجراؤها حالياً والتي من المقرر الانتهاء منها في عام 2021، ستتمكن من توفير بيانات تسهم في معالجة عدد من الفجوات الرئيسية المذكورة أعلاه.

بناءً على ما سبق ذكره في هذا الملخص حول حالة النفايات الصلبة في البلاد، والجهود المبذولة حالياً لمعالجة المشكلة من قبل مختلف الجهات المعنية، وأخذاً في الاعتبار مهمة مؤسسة الكويت للتقدم العلمي كما هي موضحة في إستراتيجيتها، فإن المؤسسة ترى أن دورها يتوجب أن يكون مكملاً لجهود المؤسسات الحكومية المعنية، لا سيما الهيئة العامة للبيئة وبلدية الكويت، وذلك من خلال توجيه ثلاثة من البرامج الإستراتيجية القائمة بالمؤسسة نحو دعم الأنشطة المتعلقة بمشكلة النفايات الصلبة على النحو التالي:

1. **زيادة التركيز على أنشطة البحث والتطوير المتعلقة بالنفايات الصلبة**: سيتم توجيه انتباه الباحثين في جامعة الكويت ومعهد الأبحاث نحو التركيز على موضوع المخلفات الصلبة من خلال "الدعوة لتقديم مقترحات" في المستقبل وذلك ضمن برنامج 1 (برنامج المنح البحثية) في إطار التوجه 2 من الاستراتيجية ويتم تحديد الأولويات وفق توصيات الجهات المعنية في الدولة وتشمل تطوير تكنولوجيات ملائمة كإعادة التدوير أو تحويل النفايات إلى طاقة
2. **تحسين أداء صناعة إعادة التدوير الحالية**: سيتم توجيه المزيد من الجهود نحو هذا القطاع من الصناعة المحلية من خلال البرنامج 3 (دعم البحوث ونقل التكنولوجيا) في إطار التوجه 3 من الإستراتيجية
3. **رفع مستوى الوعي العام لمشكلة النفايات**: ستبذل الجهود لإعداد عدد من المنشورات والبرامج الإرشادية المتعلقة بمشكلة النفايات الصلبة وفرص إعادة تدوير النفايات، وستستهدف هذه الجهود مختلف الفئات العمرية في المجتمع.

ولضمان تركيز جهود المؤسسة بشكل يتناسب مع احتياجات الدولة ومكمل لجهود الجهات الحكومية المعنية، ستقوم المؤسسة بتوزيع هذا التقرير على جميع الجهات المعنية، والتماس اقتراحات بشأن المجالات ذات الأولوية التي لا تغطيها الدراسات الحالية التي تجريها هذه الجهات وتنظيم ندوة أو مجموعة من اللقاءات مع ممثلين من هذه الجهات لمناقشة أهم مخرجات هذه الدراسة وخلق فرصة للمختصين للتباحث وتحديد أهم القضايا العلمية والفنية والثقافية التي يتوجب على المؤسسة التركيز عليها.

Executive Summary

The solid waste (SW) problem is a growing concern in the State of Kuwait and the region. KFAS Board of Directors in its meeting dated 17/10/2018 requested KFAS management to conduct a study to determine the current size of the problem, the future challenges, and the adequacy of the current and planned efforts and initiatives to address the challenges and resolve the problem. Furthermore, the study should aim at assessing the role that KFAS can play in addressing the challenges related to solid waste in the country with the objectives of supporting the development of appropriate solutions to this problem. This study was prepared in response to this request.

It was found that the SW generated in the country is reaching alarming quantities at around 12 million tons annually. Most of the waste consists of construction and demolition solid waste (C&DSW)(over 80% by weight), and the remaining waste is mostly municipal waste (MSW) and end-of-life tyres. However, for land use and degradation; it is important to note that the majority of the solid waste by volume is MSW. The MSW is a complex blend of many components consisting of organic waste (household foodstuff), paper/corrugated cardboard waste, white goods (encompassing metals), plastic solid waste (PSW), agricultural solid waste (ASW), sludge (from wastewater treatment), waste from electrical and electronic solid equipment, and others. MSW is also the most environmentally burdensome that truly requires an intervention from all concerned parties. It is the fraction that requires most sophisticated technologies and technical know-how for its valorization, and deivers the largest return on investment on an industrial scale. Most of the SW is currently being disposed of in landfill sites. The total number of sites in Kuwait is 20, occupying a total area of around 30 km^2, with 12 of them currently closed. Six of the twenty sites are dedicated for asbestos, remnants of cattle barns, and industrial liquid waste, three are for C&DSW, and the remaining are sites with mixed MSW and C&DSW. Most of these sites are either close to urban areas or will be close to urban areas in the near future as a result of urban expansion. The present method of disposal has negative impact, in terms of land degradation, health hazards, environmental pollution, and socio-economic perspectives.

In addition to the two main categories of SW that are being disposed of in landfills, there are numerous other types of SW that are more specialized and collectively add a small percentage to the total SW in the country. These include oil contaminated soils, oil-based mud cuttings of oil well drilling, sand wash from sand quarries, radioactive waste including naturally occurring radioactive materials (NORMs), hazardous industrial solid waste (ISW) generated

by various industries, such as spent catalysts from the refining and petrochemical industries, and fly ash from power generation, military waste, and others. The responsibility of the handling and safe disposal of these other types of solid waste is assigned to the generator (typically sub-contracted to a private entity) of the waste based on the regulations of the Kuwait Environment Public Authority (KEPA) and the Public Authority for Industry (PIA). Hence, they have been excluded from this report although they may pose serious environmental threat, specially that some quantities are ending up in landfills or unknown disposal sites.

The problem of solid waste handling in the country is currently addressed by a number of stakeholders, with KEPA playing the main role as a regulatory body, and Kuwait Municipality (KM) as the main execution body responsible for the collection of MSW and the management of the landfill sites. The collection of MSW is carried out through sub-contracting to private companies by the Cleaning Division at KM. The C&DSW is mostly handled by the C&D contractors, who collect the waste and transfer it to the landfills assigned by KM. Both KEPA and KM already embarked on addressing the problem in a modern and scientifically sound approach, and are currently conducting studies to ascertain the amounts and composition of SW.

KEPA contracted the Fraunhofer UNSICHT Institute Branch Sulzbach-Rosenberg, which is part of the German Fraunhofer Society, to conduct a study of a survey nature. The institute specializes in the development of processes and plants for the conversion of biogenic residues into valuable, storable products, for the recycling of composite materials and for waste management concepts for municipalities and countries. The project started in January 2017 for a duration of 4 years and will address the following four issues:

1. Inventory and collection of primary data
2. Exploration of the country's landfills
3. Creation of a web-based interactive database showing the waste and landfills in the country
4. Preparation of a national waste management plan / roadmap

The project is in progress and a web-based information system (eMISK) on environmental issues, including SW, is already in place and is publicly available. eMISK is populated with data covering a number of years. Furthermore, KEPA is also working on a strategy for handling solid waste that is expected to be ready in 2021.

KM, which plays a pivotal role in ensuring that solid waste handling is conducted in accordance with KEPA regulations, initiated a project in May 2018 with the World Bank, entitled "Kuwait Municipality (KM) Waste Management Planning Project" to address three issues:

1. Support on Municipal Waste Planning and Inputting to the National Waste Strategy
2. Support in Developing a Community Engagement Strategy on Waste Management
3. Support the Development of Waste Information system

The communication between various stakeholders needs to take place in a more effective means. KM recently formed a Working Group to support the above-mentioned project. The working group includes representatives from KM, KISR, KEPA, KU, SCPD, Ministry of Finance, Ministry of Education, and Ministry of Information.

Both KISR and KU have already conducted numerous research works related to the problem covering several aspects. Over sixty-five (65) research papers and publications were identified during the period 1990 to present. KFAS have also supported a number of research projects related to the subject. Among these studies is a study requested by the Industrial Bank of Kuwait and was completed in 2010. It was funded by KFAS and Ministry of Finance and was conducted by the World Bank. The study addressed three issues:

1. Assessment of current solid waste sector conditions
2. Assessment of waste recycling investment opportunities
3. Private sector participation and incentive mechanisms

It is also useful to recognize that there has been a drive to encourage the waste recycling industry. The Ministry of Trade and Industry has a list of 33 companies registered as establishments for processing and recycling solid waste; however, it appears that a number of these companies do not have recycling facilities. Hence, they are probably either inactive or are involved in trading with solid waste. KEPA has also a list of 26 companies, which presumably are involved in some activities related to waste recycling, collection or exporting. There is lack of information concerning the performance of these companies and the level of their contribution to the reduction of solid waste in the country.

Through this study, a number of gaps have been identified covering various aspects related to the SW problem. The main gap is the lack of a management philosophy based on benchmarking and benefiting from the experiences of other countries that have made significant advances in processing solid waste. Other gaps include the absence of adequate data on the sub-composition of solid waste, the lack of a clear socio-economic assessment of

the impact of the problem, limited materials to enhance public awareness on their role in collection and segregation, the need to adapt some recycling technologies to local conditions, policies that addresses restrictions or banning of certain substances whether manufactured or imported, and legislative and legal issues. Based on the findings of this report, it appears that KEPA and KM, through the studies that are currently being conducted and are due to be completed in 2021, a number of the main identified gaps are expected to be addressed.

Taking into consideration the above briefing on the status of SW in the country, the efforts that are currently taking place to address the problem by various stakeholders, and KAFS mission, it was concluded that KFAS can complement the efforts of the current stakeholders, particularly, KEPA and KM, by directing partially the following three KFAS strategic programs to activities related to the solid waste problem:

1. To increase research activities related to solid waste, the future "Calls for Proposals" for Program 1 (The Research Grant Program) under Thrust Area 2, will direct attention to the subject
2. To improve the performance of the existing recycling industry, Program 3 (Research Support and Technology Transfer) under Thrust Area 3, will direct more efforts towards this segment of the local industry
3. To improve public awareness, efforts will be made to prepare a number of publications, programs, and events related to the solid waste problem and the opportunities for waste recycling. These publications and activities will be targeted to all age groups and segments of the society.

To ensure that KFAS efforts are appropriately focused to the needs of the country, KFAS will distribute this report to all stakeholders and seek their suggestions on priority areas not covered by current studies conducted by them. KFAS will also organize a seminar or a series of meetings with the stakeholders' representatives to discuss the main outputs of this study and identify the most important scientific, technical and public awareness issues that KFAS should focus on.

ACKNOWLEDGEMENTS

This report was prepared by Dr. Mamun Absi Halabi (Principal Scientist/Consultant), Dr. Eng. Sultan Al-Salem (Research Scientist and Program Manager/Environment Pollution and Climate Program, KISR), Dr. Esra Aleisa (Associate Professor/Department of Industrial and Management Systems, Kuwait University), Eng. Suad Al-Bahar (Research Scientist, Program Manager/Building and Construction Material Program, KISR), Dr. Samir Al-Ghawas (Research Scientist, Agriculture Program, KISR), Dr. Rawaa Al-Jarrallah (Assistant Professor, Department of Civil Engineering, Director of Evaluation and Measurement, Kuwait University), Dr. Essam Omar (Consultant, KFAS), Eng. Dina Alnakib (KFAS)

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Abbreviations

ASW	Agriculture Solid Waste
C&DSW	Construction and Demolition Solid Waste
CSW	Commercial Solid Waste
ELSRC	Environment and Life Science Research Center at KISR
ELTs	End of Life Tyres
eMISK	Environmental Monitoring Information System of Kuwait
IBK	Industrial Bank of Kuwait
KEPA	Kuwait Environment Public Authority
KFAS	Kuwait Foundation for the Advancement of Sciences
KISR	Kuwait Institute for Scientific Research
KM	Kuwait Municipality
KOC	Kuwait Oil Company
KU	Kuwait University
MENA	Middle East and North Africa
MPW	Ministry of Public Works
MSW	Municipality Solid Waste
PAAFR	Public Authority for Agriculture and Fish Resources
PIA	Public Authority for Industry
PSW	Plastic Solid Waste
SCPD	Supreme Council for Planning and Development
SW	Solid Waste
SWM	Solid Waste Management
WEEE	Waste from Electrical and Electronic Equipment
WMRU	Waste Management Research Unit at KISR
WtF	Waste to Fuels

1. Background

Decision of the KFAS BOT No. 163

KFAS Board of Directors in its meeting dated 17/10/2018 requested KFAS management to conduct a study to determine the current size of the solid waste problem in the country, the future challenges, and the adequacy of the current and planned efforts and initiatives to address the challenges and resolve the problem. Furthermore, the study should aim at assessing the role that KFAS can play in addressing the challenges related to solid waste in the country with the objectives of supporting the development of appropriate solutions to this problem.

Environmental and societal challenges and implications of the solid waste problem in Kuwait.

Solid waste (SW) is a growing problem in Kuwait. The total current amount generated is estimated at over 10 million tons annually. Its main components are municipal solid waste (MSW), construction and demolition solid waste (C&DSW), sludge from sewage wastewater treatment, agricultural solid waste (ASW) and end of life tyres (ELTs). Based on several studies, the rate of solid waste generation in the country is estimated at around 5.5-5.7 kg/capita/day, of which municipal solid waste contributes around 1.1-1.5 kg/capita/day, and the remaining is mostly construction and demolition solid waste. The above figures do not include other special SW generated or existing in the country such as oil contaminated soil, sand fines from construction sand washing, industrial hazardous and non-hazardous waste, radioactive waste, and health care waste.

The majority of the waste in the country is currently being dumped in unsanitary landfill dumpsites. The total number of sites is 18 sites, with 12 sites already closed. In addition, two new sites are being developed for opening including one sanitary landfill. The total area occupied by these sites is estimated at nearly 30 km^2. Due to fast-paced industrial development and urban expansion in the country, some of the landfills are already located on the edges of residential areas, as is the case of Jleeb Al-Shuyoukh, Yarmouk and Al-Qurain sites. Most of the landfill sites have already been forced to close, much before achieving their capacities, because of improper disposal methods and concerns related to public health and

environment. In fact, landfilling in Kuwait is noted to be practiced in an unsanitary manner for over thirty years. The prevailing method is disposal in ditches rather than properly engineered landfills with potential energy recovery provisions. Furthermore, with further urban expansion in the future, all the landfill sites are expected to be close to urban areas. It is important to mention that a relatively small percentage of solid waste is currently being recycled, and a number of recycling companies are operating in the country. In addition, some waste plastic and metals are also being collected and exported to countries such as Lebanon, Jordan and Egypt. The use of open dump sites as a means of SW disposal or unsanitary landfilling are potential sources for health problems and may contaminate underground water aquifers. The lack of appropriate recycling solutions also burdens the economy of the country, which has to deal with the clean-up processes associated with the accumulation of waste. The World Bank report on Asian countries Waste Management (WM) *status-quo* showed that local municipal authorities may need to spend up to 70% of their revenue on Solid Waste Management (SWM) alone (AIT/UNEP, 2010).

The implications of the solid waste problem in the country can be summarized by the following:

a. Land Degradation. The State of Kuwait (29˚30'N lat. and 47˚45' E long.) occupies a land area of 17,818 km^2 on the Arabian Gulf Peninsula of the Middle East, and it is one of the high-income countries in the Middle East. Kuwait has shown a steady population growth since 1994 reaching approximately 4.1 million in 2017 (Statistical Report, 2018). The climate is characterised as arid with summer temperatures (between June and August) exceeding 50°C with an annual average precipitation of 110 mm. Land in Kuwait for urban development is limited. Solid waste landfills is already occupying 30 km^2, and they are located in relatively close proximity to urban areas. Furthermore, over the next 30 years, and assuming that solid waste generation will continue at the current rate, additional land will have to be allocated for landfills, bringing the total area to probably more than 50 m^2. If we further assume that urban areas should be located at least 500 m away from landfills, the total area that will be excluded from urban development will nearly double, i.e. nearly 100 m^2.

b. Environmental considerations. The increased generation of waste, and the current practice of dumping the waste in landfills is causing significant environmental degradation, in particular pollution of land, water, and air due to unsustainable waste disposal and management methods. On the one hand, and according to the Intergovernmental Panel on Climate Change (IPCC) report, the waste sector contributes around 5% of global GHG emissions. The gases emitted are mostly methane and CO_2, but they also contain a number of other gaseous or vapour chemicals, such as carbon monoxide, hydrogen sulphide, di- and tri-chloroethanes and chloromethanes, ethane, butane, propane, and others. The amount of biogas emitted is on the average 150 m^3/ton of municipal solid waste (Bialowiec, A. 2011). In addition, the landfill may produce around 500 $m^3/km^2/d$ of highly polluted leachate, and there is always possibilities of migration of the leachate beyond landfill site boundaries. This results in contamination of groundwater specially since the groundwater in Kuwait occurs at shallow depths throughout the country. For selected Kuwait landfill sites, Al-Yaqout et al. (2005) came to the following conclusions based on a study of the leachate and emissions from both open and closed landfills:

- Liquid waste/sludge co-disposal is the major source of leachate generation. The runoff and precipitation have virtually minor effect on the quantity of leachate produced from landfills
- The main liquid waste streams identified in landfills in Kuwait contain high concentrations of suspended solids, volatile suspended solids, total dissolved solids, chemical oxygen demand (COD), sulfate and heavy/toxic metals. They are continuously formed in all operating landfills in Kuwait, and it is a big threat to groundwater and aquifer system which is second major potential source of drinking water supply in Kuwait.
- A relatively less toxic and low organic strength leachate is being produced in closed landfills compared to operating landfills.
- A high rate of landfill gas production has been noted at the closed landfill. This could be due to continuing decomposition of a large quantity of organic waste with high moisture content from the rising water table in the landfill. The methane content was

found to be more than 50% v/v, which clearly indicates the danger of explosion and fire hazards at the landfill.

In avoiding environmental problems and burdens associated with landfill disposal, attempts were made by researchers in Kuwait to study the impact of certain waste management practices. Ziad (2014) reported the abundance of finer sized clay particles in landfills of Kuwait providing a significant adsorption route and retention behaviour of leachate and chemicals. Landfills have also been deemed as a contamination source of ground water and soil, in terms of inorganic pollutants (Al-Fares and Al-Jarallah, 2011).

c. Health hazards. Both gas emissions and leachates are highly likely to pose health hazards to the urban communities near the landfill site. Furthermore, landfills are often infected by rodents, which pose another health hazard. Fire balls are also associated with mismanaged waste disposal as it was evident from various incidents around the world, and in particular Kuwait with ELTs disposal site being a prime example. Characterizing heavy metals (e.g., arsenic, lead, cobalt, copper, mercury, and nickel) concentration and organic pollutants presence in soil is essential for the surroundings safety, health concern and environmental protection/hygiene. Ingestion, inhalation, and skin contact are the main ways of human exposure to heavy metals which are considered among the most dangerous environmental pollutants, because they do not disintegrate and remain in the soil for prolonged periods of time. Polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) are two of the organic pollutants in soil that pose a great concern due to their persistence and bio-accumulative nature (Mora, 1996, Guitart et al., 1994), imposing a threat on the reproductive functionality in wildlife (Custer et al., 2000). Furthermore, PAHs are considered environmental contaminants with high potential carcinogenicity (Metre et al., 2000). Assessing the concentration and mobility of heavy metals and the pollutants in soil is essential for planning and development of landfill restored sites and is important for determining site potential usage: agricultural, commercial, residential, or industrial. Some health hazards are also expected to be associated with certain actions that may be taken in the future for the restoration of the landfills, as was demonstrated by Al-Salem (2017) for the potential incineration site to be commissioned by KM, and Al-Salem et al. (2018a; 2018b) for the

possible restoration and future development of the South Seven Ring Road (SSRR), Mina Abdullah (MAB) and A-Jahra landfill sites, through waste-to-energy treatment plants.

d. Economic losses. The most significant economic losses concerning the current handing of solid waste in Kuwait is the loss of lands designated for landfills, and the losses associated with health hazards and the environmental problems that landfills create. Secondary economic losses is the potential use of waste as recycled resources. However, in many developed countries, recycling of solid waste is currently not favoured due to health hazards of material recovery and sorting facilities, and the complex material structure and assembly of many products. Furthermore, the cost effectiveness of recycling technology for many categories of solid waste is low, compared with virgin materials. Hence, waste recycling is currently confounded to specific waste categories such as metals, some elements, gravel, oils and maybe tyres. The new inclination is to avoid recycling plastics, since eco labelling is showing more promise. For organic waste, conversion of the waste to fuels by thermal degradation is considered as a better route for the disposal of this category of waste over recycling or composting. Furthermore, the global trend concerning solid waste handling is in the direction of adopting waste management systems, which primarily relies on technology driven 'end-of-life' waste collection, management and treatment systems.

Despite the above-mentioned global trends, material recovery from some of the solid waste by recycling techniques in Kuwait may have direct benefits in generating primary and secondary materials. The material and environmental benefits of resource recovery from waste may bear some economic benefits, since the country lacks many virgin resources. For example, waste construction and demolition materials can be converted to products that replace aggregates. Organic waste and tyres can be converted to fuels by thermal degradation and sludge from wastewater treatment can potentially be used as organic fertilizer if properly treated (Appendix 3). Alternatively, organic MSW and agricultural waste could be converted to composts that can be used as soil modifiers to replace imported mulch if health hazards can be avoided. However, it appears from efforts conducted in developed countries, that recycling may carry with it serious health hazards and is often not cost effective. Therefore,

adopting recycling routes in Kuwait must be subjected to careful cost-benefit assessment including the consideration of environmental externalities.

Current activities for the treatment of solid waste in Kuwait.

The solid waste is currently handled by several government bodies, Kuwait Environment Public Authority (KEPA – regulatory body), Kuwait Municipality (KM – management of MSW comprising commercial and household SW), Ministry of Health (MOH – Medical Waste), Ministry of Public Works (MPW – Sludge management) and Public Authority of Industry (PAI – Industrial/Hazardous Waste). KEPA works as a regulatory body and has already started a systematic effort to address the problem. Among these efforts are initiating systematic efforts to survey and monitor the quantities and composition of solid waste generated in the country, as well as the composition of solid waste already existing in closed landfills. The data generated is stored in a knowledgebase accessible to the public (eMISK). KEPA is also working on developing a strategy to address the problem, which is expected to be completed in 2021. KM is currently responsible for collecting municipal solid waste throughout most of the state contracting private sector companies to carry out this work. KM is also managing the landfill sites. In addition, KM already initiated a project in collaboration with the World Bank on May 2018 entitled "Kuwait Municipality (KM) Waste Management Planning Project". The project is supported by a working group with representatives from KM, KEPA, Ministry of Finance, KISR, KU, Ministry of Education, and Ministry of Information. The project duration is 2 years and addresses a number of key issues that will be elaborated on in a later section of this report. Neither KEPA nor KM have yet put regulations to reduce or segregate SW, with the exception of standardizing the use of biodegradable plastic bags by KM after reviewing and putting forward the recommendations of the Environment & Life Sciences Research Centre (ELSRC) of KISR.

In addition to the aforementioned bodies, The Public Authority of Agriculture and Fish Resources (PAAFR) is also handling some of the agricultural solid waste, such as sheep and cattle carcasses, and green waste. The petroleum sector, specifically Kuwait Oil Company, is also responsible for handling its solid industrial waste as well as other solid waste generated from various sites of its operation. Some of KOC waste is being segregated and recycled and the remaining is disposed of in landfills. Hazardous waste is disposed of by incineration and/or landfilling. The medical solid waste is handled by the Ministry of Health and is also disposed of through incineration or autoclaving.

There are over 20 private companies that are registered in recycling some of the solid and liquid waste. They include a company active in building material waste, another company working on waste tyres, and a number of companies involved in collecting waste plastics, paper, cartons, packaging materials, and used lube oil. Systematic efforts to segregate solid waste is not practiced. Most segregation is done by voluntary efforts at source and by 'scavengers' at landfill sites.

Regarding research efforts, Kuwait Institute for Scientific Research has recently established a dedicated facility (e.g., **Waste Management Research Unit - WMRU**) for the development of technologies to converting organic waste to fuels (WtF), recycling and safely disposing of solid waste. The WMRU at present consists of one dedicated analytical and characterization laboratory, one pilot plant facility and one station for organic waste management (Kabd Campus – KISR). The WMRU has also started building a three-story dedicated building within KISR main campus to host a specialised waste management and valorisation program within its 9th strategic program. The research work related to this area at KISR is conducted through three programs:

- The Environmental Pollution and Climate Program/Environment and Life Sciences Research Center which handles all types of solid waste management and disposal research
- The Desert Agriculture and Ecosystems Program, which focuses on various techniques and research on valuable by-products from composting of agricultural wastes, such as poultry waste, plant wastes, animal mortality wastes, yard wastes, etc.
- The Construction and Building Materials Program/Energy and Building Materials Research Center which handles C&DWS research works.

A number of research studies have been conducted mainly focused on organic waste management, MSW management and landfill site assessment, ELTs valorisation and fuel recovery, waste building material, PSW and gasoline production from SW. KISR has recently developed a product applicable for the Kuwaiti market from PSW which also complies to international standards. Through the ELSRC, KISR has conducted various successful projects with KM, KFAS, The British Council (Gulf Council Institutional Link), Supreme Council of Planning & Development and EQUATE Petrochemical Company in PSW management and product development from recycling processes.

At Kuwait University, research work is conducted by the Civil Engineering Department/College of Engineering and Earth and Environmental Sciences/College of Science. KU researchers published numerous papers based on research studies concerning solid waste that have been conducted at the University.

The overall aim of the study

This study is conducted with the aim of preparing a report on solid waste in the State of Kuwait, the estimated quantities, the key players involved in addressing this issue, and the research efforts that has been conducted on this subject. The report will serve as an initial document for various stakeholders to join their efforts in accelerating the development of a roadmap for addressing and resolving the solid waste problem effectively. KFAS have taken the initiative of preparing this document to identify the role that it should play in supporting scientific research and technological development efforts to bridge the existing technological gaps related to the nature of the solid waste problem in Kuwait.

2. Objective

The objective of the study is to identify existing major gaps in solid waste disposal and treatment in Kuwait and the needed interventions, research projects or programs that KFAS should support to develop solutions to the solid waste problem in the country.

3. Available Data on Solid Waste in Kuwait

Estimated daily or annual quantities

Data on current solid waste sent to landfills are spread over many years. These data were mainly generated by researchers from KU and KISR. KEPA, in cooperation with KM, is currently conducting a continuous survey on the quantities of solid waste that enters the open landfills. Not much information is available on the closed landfills. However, from the studies that has been conducted so far, it can be concluded that an average person in Kuwait generate 1.1-1.5 kg/person/day of MSW (Koushki and Khaleefi (1998); Koushki et al. (2004); (Al-Salem and Al-Samhan, 2007); and others). This is excluding construction and demolition solid waste. According to Koushki et al. (2004), the total weight of MSW increased from 268,248 tons/y in 1986 to 800,000 tons/y in 2002, and the total solid waste in Kuwait from all urban sources was estimated to be 2.265 million tons/year in 2002. In 2008, a study conducted by the World Bank for the Industrial Bank of Kuwait (IBK, 2010) estimated the C&DSW at around 4.6 million tons, the MSW at 1.2 million tons, and industrial waste at around 47,200 tons.

The total solid waste was also reported by Alsulaili et al. (2014), utilizing data derived from a report by the Industrial Bank of Kuwait covering the years 2002 to 2011 (Table 1; Figure 1),

and covers both MSW and C&DSW. Al-Essa and Al-Jarrallah (2014) reported similar figures for the total municipal waste as shown in Figure 2. Statista (2018) reported that the total solid waste is currently around 12.64 million tons, distributed among different broad categories as shown in Table 2, however, the source of their data is not known. If we take into consideration the economic growth that took place during the period 2011 to 2015, and the trends shown in Figure 2, the number reported by Statista could be close to reality.

In addition to the above, Al-Qallaf et al. (2016) provided data on the waste generated by KOC, both hazardous and non-hazardous by all sites that are under the jurisdiction of the company. Focusing on non-hazardous waste, KOC generated in 2014 and 2015, total amounts of 14,752 Tons and 13,894 Tons, respectively of non-hazardous waste.

Table 1. Waste Quantities in Kuwait (Alsulaili et al., 2014)

	Domestic Solid Waste (Tons)	Construction Waste (Tons)	Total Solid Waste (Tons)
2002	1,059,880	4,792,780	5,852,660
2003	976,185	3,797,770	4,773,955
2004	840,005	4,309,200	5,149,205
2005	836,610	4,718,370	5,554,980
2006	987,295	4,187,909	5,175,204
2007	1,000,565	3,926,280	4,926,845
2008	1,310,036	4,421,565	5,731,601
2009	1,153,233	3,606,804	4,760,037
2010	1,408,433	4,165,855	5,574,288
2011	1,350,645	6,897,786	8,248,431

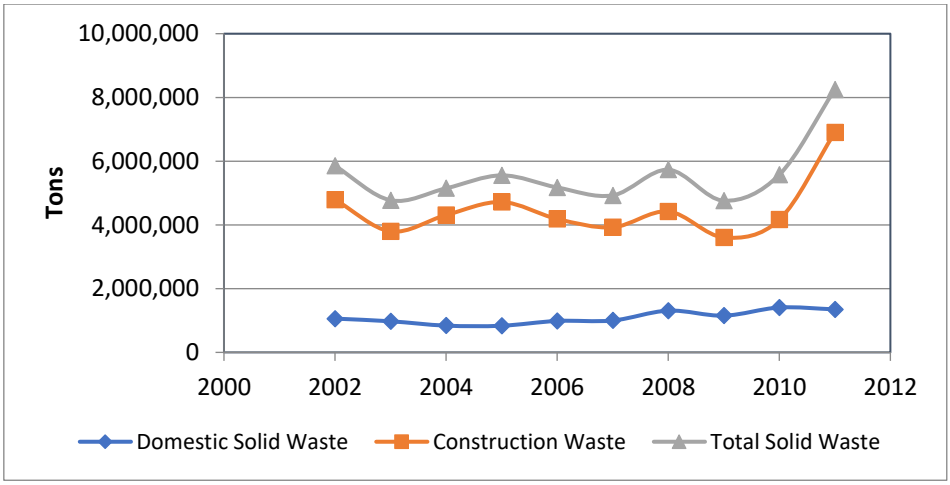

Figure 1. Solid waste generated during the period 2002-2011.

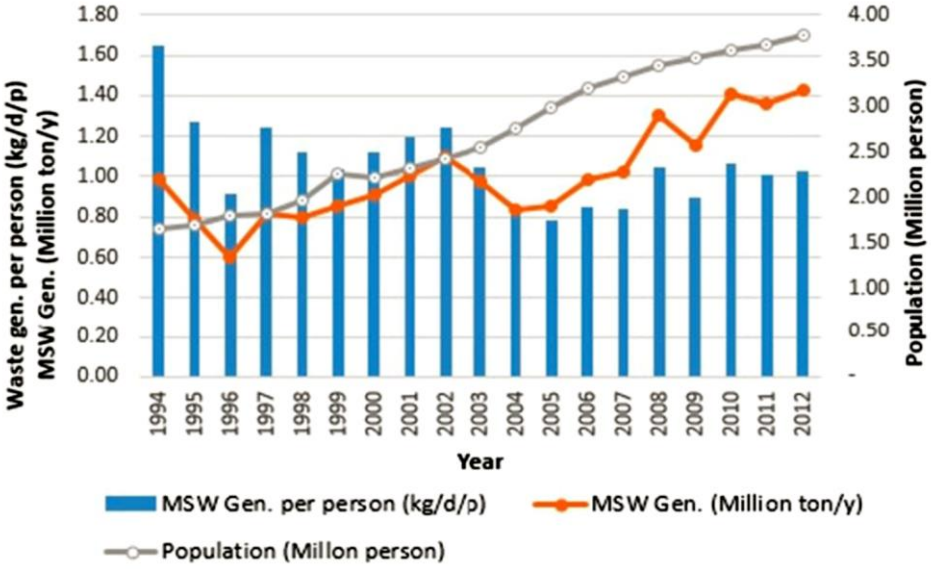

Figure 2. Estimated municipal solid waste generated and solid waste per capita (Aleisa and Al-Jarrallah, 2014).

Categories of solid waste

The solid waste is broadly divided into construction and demolition (C&DSW), household or municipal (MSW), commercial, and agricultural solid waste (ASW). The percentages are listed in Table 2, which shows that the majority is construction and municipal wastes. The C&DSW is mainly a mixture of demolished construction material of old and renovated buildings, reclaimed concrete from ready-mix companies, or reclaimed asphalt pavement materials. A number of studies attempted to classify municipal solid waste into different sub-categories using different methods and waste classifications. The studies were conducted at different years. Most studies were done using samples at origin and cover a large number of samples

from different locations in the country. The results are shown in Table 3. It does not appear that a survey was made of the categories at the closed or open landfill sites. KEPA is currently conducting studies in this direction, but the details of these studies need to be clarified. For non-hazardous waste generated at KOC sites, the company conducts a monitoring program, which includes identifying the composition of waste. Figure 3 shows the distribution reported by the company for 2015 (Al-Qallaf et al., 2016). Naturally Occurring Radioactive Materials (NORM), oil contaminated sands and oil-based mud cuttings are excluded.

The above studies clearly indicate that in general, the municipal solid waste is composed of nearly 45-50% organic/food, 15-20% paper/cardboard, 13-19% plastic material, 3-6% glass, 3-10% metal/cans, and other materials 5-10%.

Table 2. Estimated Solid Waste in Kuwait by General Category in 2015 (Statista, 2018)

Type of Waste	Amount (tons)	Percentage
Construction Waste	10,378,027	82.1
Household Waste	1,527,878	12.1
Commercial Waste	368,934	2.9
Agricultural Waste	364,620	2.9
Total	**12,639,459**	**100**

Table 3. Percentage of Measured Proportion of Municipal Solid Waste Compositions

Category of Waste	Koushki & Khaleefi (1998)	Koushki & Al-Humoud (2002)	Alsulaili et al. (2014)*	Aleisa and Al-Jarrallah, 2014
Foodstuff	51.1	45.6	50	46
Paper/Cardboard	18.6	14.5	21	15
Plastic	13.4	16.0	13	-
Plastic (Nylon)	-	-	-	12
Plastic (PET)	-	-	-	7
Glass	4.5	4.7	3	6
Cans/metals	5	9.9	3	4
Textiles	-	-	5	-
Wood	-	-	-	4
Other	7.5	9.3	5	6
Total	100	100	100	100

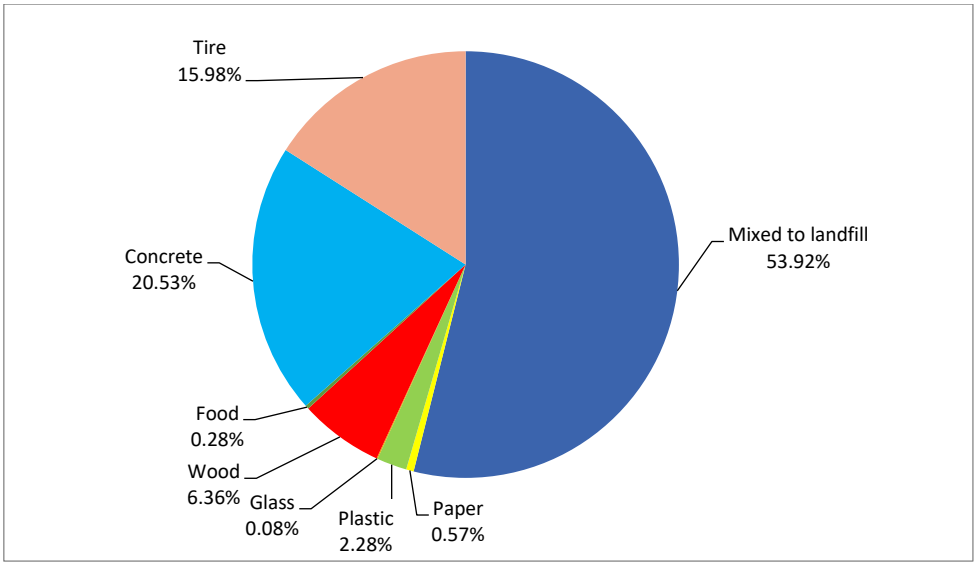

Figure 3. Distribution of non-hazardous waste generated by KOC in 2015.

Waste Disposal Sites

There is currently a total of 20 landfill sites allocated for solid waste. All landfill sites are managed and controlled under state regulations by Kuwait Municipality (KM) as the governing body is solely responsible for collection and disposal of MSW. Table 4 provides a list of these sites, their location, status, and type of solid waste handled. The location of the sites are shown in Figure 4. Of these sites, 6 are currently active or open and 2 are in progress. Only three of the open sites are allocated to MSW and C&DSW. The two sites which are in progress are allocated to recycling and industrial liquid waste. The total area of the landfills is estimated at 30 km^2 and with waste deposition depth varying from 3 to 30 meters. In addition to these sites, there are few sites that are used by PAAFR to dispose of agricultural waste.

Table 4. Landfill Sites in Kuwait

	Name	Name/Arabic	Operating Year	Area (km^2)	Status	Remarks
1.	Sabhan Block 11	صبحان قطعة 11	1986	0.13	Closed	Site of old building material dumping
2.	North of the Seventh Ring Road	شمال الدائري السابع	1986	6.27	Closed	Site of old building material and liquid waste dumping
3.	Jleeb Al-Shuyoukh	جليب الشيوخ	1993	5.56	Closed	Site of household, construction, oil and other liquid waste dumping
4.	East Sulaibiyah	شرق الصليبية	1987	0.24	Closed	Site of old building material dumping
5.	Sulaibiyah	الصليبية	1982	2.78	Closed	Site of old household waste and liquid waste
6.	Al-Rai	الري	0	0.21	Closed	Site of an old asbestos factory with remnants of buried asbestos
7.	Wastern Yarmouk	اليرموك	0	0.42	Closed	Site of old construction waste material
8.	Military base Sabhan/ Messila	صبحان العسكري / المسيلة	1984	2.3	Closed	Site of building and household waste dumping
9.	Al-Qurain (EAST)	القرين	1984	0.58	Closed	Site of old building material and household waste under rehabilitation and recycling for liquid and gaseous leachate
10.	Failaka	فيلكا	0	0.34	Closed	Site of old building material and household waste
11.	Egaila	العقيلة	0	0.1	Closed	Site of old building material and household waste
12.	Kabd Animal Waste Dumping Site	كبد مردم النفايات الحيوانات النافقة	1999	0.32	Closed	Site of buried remnants of cattle barns
13.	South of the Seventh Ring Road	جنوب الدائري السابع	1992		Open	Site of household waste and effluents dumping
14.	Shuaiba Asbestos Waste Storing Site	موقع الشعيبة لتشوين الاسبست	1984	0.29	Open	Asbestos waste storing site
15.	Mina Abdulla	ميناء عبدالله	1991	1.11	Open	Site of old building material and liquid waste
16.	South of the Seventh Ring Road - Kabd	جنوب الدائري السابع - كبد	2012	1	Open	Site of buried remnants of cattle barns
17.	Al-Jahra	الجهراء	1986	1.98	Open	Site of old building material and liquid waste
18.	Asbestos Dumping Site	موقع الاسبستس الجديد	2014	1	Open	New asbestos dumping site
19.	Al-Qurain	القرين	1984	0.3	In progress	Site of waste recycling and remediation under management and development of Kuwait Municipality
20.	Industrial Wastewater Gathering Site - KM 14	موقع تجميع النفايات السائلة - 14كم	0	1.14	In progress	Industrial Wastewater

(Source: http://data.beatona.net/dataset/landfill-sites/resource/1029fdc7-e129-4aa8-9a0e-9c96f044d8b0?view_id=81c9ec78-1cd1-4328-a73c-ee9e98ee4fde)

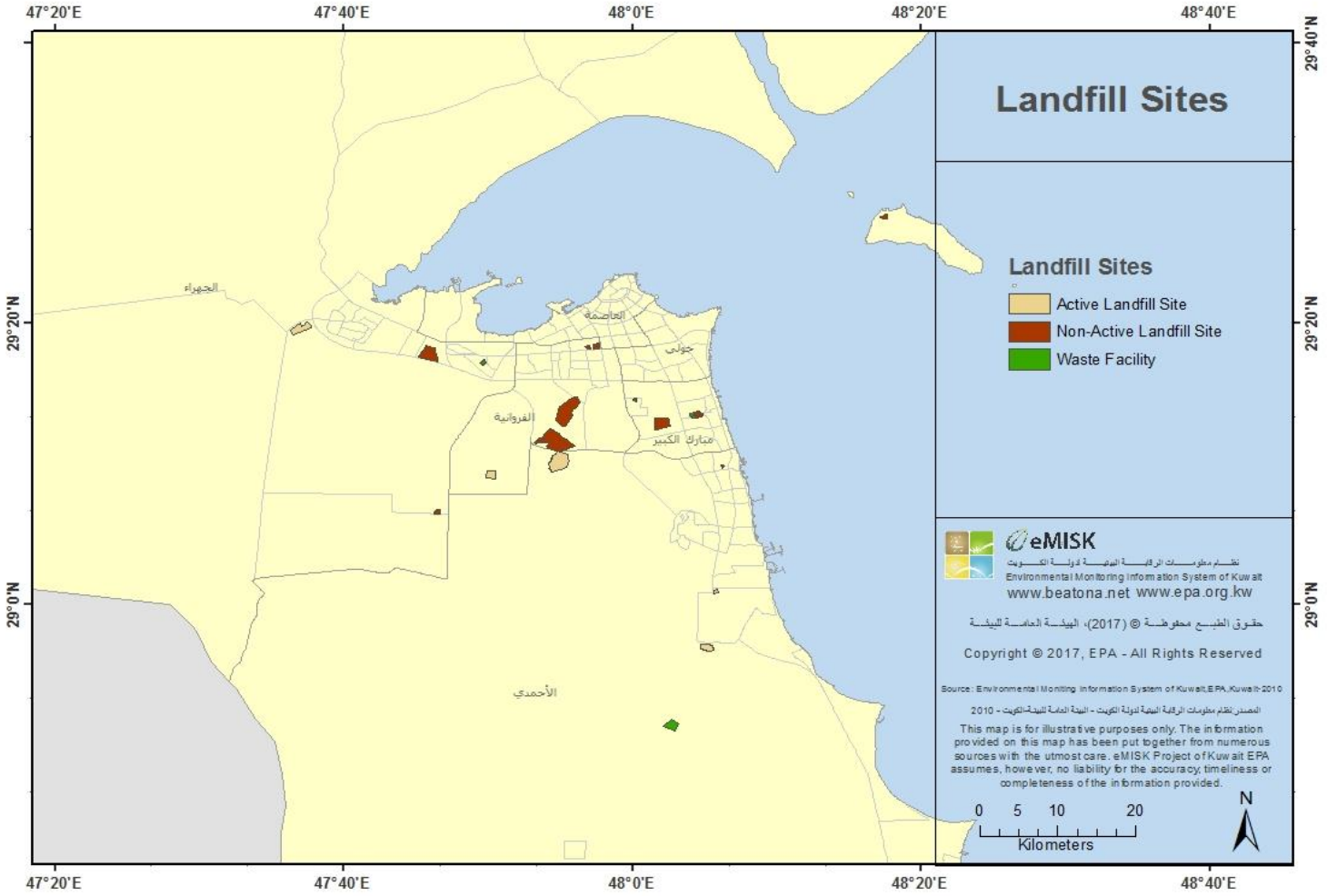

Figure 4. Location of landfill sites in Kuwait (source: http://data.beatona.net/dataset/landfill-sites/resource/7202a0ca-1a0f-4de0-8f16-1f5505b686f8)

The three active landfills for MSW are South Seven Ring Road (SSRR), Mina Abdullah (MAB) and A-Jahra. These landfills operate daily and all MSW of the country is buried within their facilities. Cross-contamination from other waste components is also present in these sites, where industrial solid waste and waste from electrical and electronic equipment (WEEE) gets through their gates. The SSRR site is considered the main landfill site in Kuwait and has processed over 976,995 tonnes of household solid waste (MSW) in the year 2015 according to KM statistics. Fig. 5 shows the amount of landfilled waste within the active landfill sites in Kuwait in the year 2015. Table 5 and Figure 6 show clear trends of an increase in the disposal for the overall solid waste, as well as each of the main four categories disposal with respect to each landfill over the past decade in Kuwait. Future plans within Kuwait also include the establishment of one sanitary landfill site that is dedicated for MSW activities and might result in closing one or more of the current active landfills. This announcement has embarked state level controversy as to rehabilitating present active landfills in Kuwait.

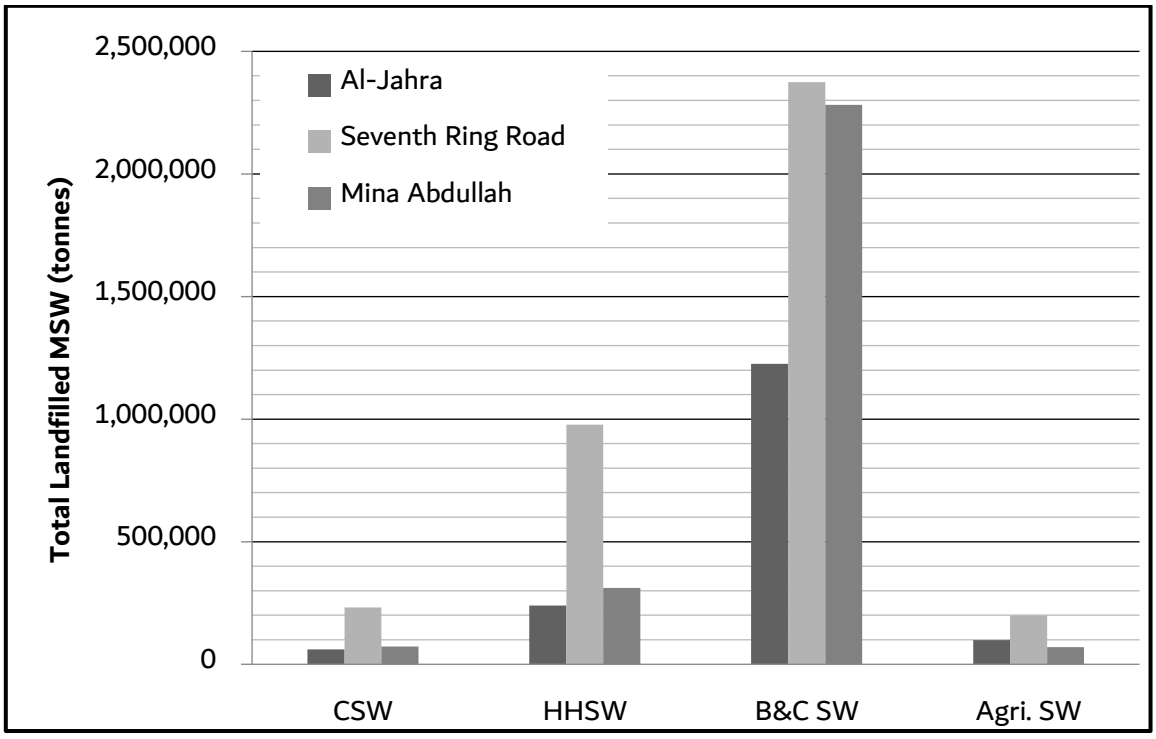

Figure 5. Landfilled Solid Waste Capacity in Kuwait (2015). Note: CSW: Commercial Solid Waste, HHSW: Household solid waste, B&C SW: Building & Construction Solid Waste, Agri. SW: Agriculture Solid Waste. Source: Al-Salem et al. 2018a.

Table 5. Landfilling Capacity (million tpa) of the Three Active Landfill Sites in Kuwait. Source: Al-Salem (2017).

Year	Seventh Ring Road (South)			Al-Jahra			MAB		
	HHSW	B&C	Comm. & Agri.	HHSW	B&C	Comm. & Agri.	HHSW	B&C	Comm. & Agri.
2005	0.46	1.27	0.13	N/A	N/A	0.67	0.18	0.79	0.05
2006	0.77	2.93	0.23	0.03	0.07	0.99	0.17	0.93	0.055
2007	0.80	1.50	0.50	0.07	0.08	0.19	0.13	0.37	0.04
2008	0.91	0.74	1.33	0.22	0.04	0.69	0.17	0.37	0.07
2009	0.71	1.38	0.43	0.23	0.05	0.86	0.20	0.07	0.69
2010	0.89	1.34	0.37	0.28	0.06	0.87	0.22	0.09	0.85
2011	0.84	1.35	0.28	0.28	0.08	0.93	0.22	0.10	1.03
2012	0.87	1.47	0.31	0.28	0.07	0.71	0.26	0.11	0.87
2013	0.87	1.43	0.28	0.33	0.11	0.59	0.27	0.12	1.31
2014	0.98	1.87	0.34	0.25	0.14	1.22	0.25	0.11	2.27
2015	0.97	2.37	0.43	0.24	0.16	1.22	0.31	0.14	2.28

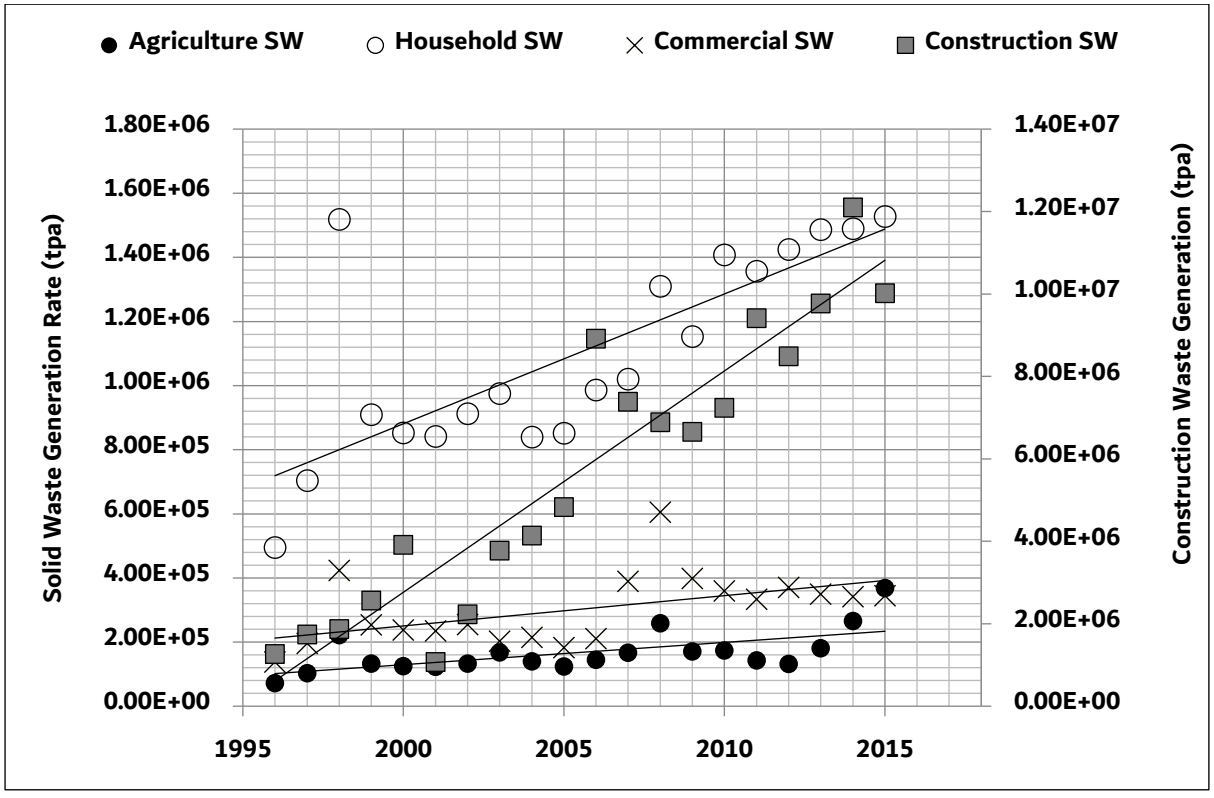

Figure 6. Annual Solid Waste Generation Rates Considered in This Work. Note: Secondary Axis Depicts Construction Solid Waste Generation Rate Adjusting to Considered Unit For Ease In Readability. Source: Al-Salem et al. (2018c)

4. Main Stakeholders and Overview of their Actions

Kuwait Environment Public Authority

KEPA is the main government body responsible for managing solid waste. In accordance with Law Number 42/2014 and the revisions Number 99/2015, Articles 28-37 and Article 39 address various aspects related to solid waste management. Within the administrative structure of KEPA, the Waste Management Department (إدارة المخلفات) is assigned the responsibility of all functions related to solid waste monitoring and management. The Department is a unit within the Environmental Monitoring Directorate. The Department include 4 sections: The Waste Disposal, The Municipality Waste, The Medical Waste, and the Commercial/Industrial Waste Sections.

KEPA has initiated several initiatives that aims at improving the management of Kuwait environment. Among these initiatives:

a. eMISK – Environmental Monitoring Information System of Kuwait. The system is already populated with extensive data, and is planned to be continuously populated with data, so that up-to-date data becomes available to the public at all times. eMisk is accessed at http://www.emisk.org/emisk/.
b. Beatona – Our Environment Website (http://www.beatona.net/), which provides access to various data (http://data.beatona.net/) including data related to waste: http://data.beatona.net/group/waste

The concerned department within KEPA is currently working on a major project entitled "A waste management plan for the State of Kuwait - eMiskWaste Project", in collaboration with the Fraunhofer UNSICHT Instiute Branch Sulzbach-Rosenberg, which is part of the German Fraunhofer Society. The size of the project is reflected by its budget, which is estimated at around EURO 18 million for a duration of 4 years starting January 2017 and ending in 2021. The details of the project are schematically described in Figure 7, and it consists of 4 phases:

– Phase **1**: Inventory and collection of primary data**.** The project will provide a comprehensive inventory and collection of primary data. In addition to municipal

waste, commercial and industrial waste, construction waste, agricultural waste, hospital waste, industrial waste-water and sewage sludge will be examined with regard to volume, composition, sources and disposal routes. The objective is to find out in detail the quantities of waste and its composition, what routes the waste takes and what the condition of the landfills are. A sorting station was commissioned at Jleeb landfill in October 2018.

- Phase 2: Exploration of the landfills. The landfills will be explored with regard to their extent, composition and the hazard potential for humans and the environment. In addition to the simulation of landfill gas and seepage water quantities. Drilling was carried out and gas, seepage water and groundwater measuring points were set up. Furthermore, geophysical investigations were carried out and waste samples are taken.
- Phase 3: Creation of a web-based, interactive database showing the waste and landfills. A web-based, interactive geoinformation system (eMISK) is being developed to make the data usable for authorities and government and to inform the public. This system will enable individualized situation analyses, graphical data evaluation and the localization of waste producers, waste treatment plants and landfills. In addition to statistical data and results of laboratory analyses, data from various sensor systems - such as odour emissions recorded in real time in the vicinity of landfills and treatment plants - are fed into the system online. The main task of the project is to create a database showing the waste and landfills in the country. The system provides real-time data on the environmental situation of all landfills and waste facilities. In addition, the eMISK monitoring system should display exceeded limit values or make the path of the waste visually traceable - via smartphone.
- Phase 4: Preparation of a national waste management plan / roadmap. The last phase of the project will work on developing a national waste management plan for the country. The existing legal framework will be further developed and a financing model for the implementation of the waste management plan will be created. A roadmap will set waste management targets, indicators and action plans for the implementation of waste prevention and recycling measures and for the remediation of landfills over the next 20 years.

Figure 7. The eMISK waste project currently conducted by KEPA and Fraunhofer UNSICHT Institute.

Kuwait Municipality

Kuwait Municipality is responsible for collecting, transporting and disposing of the solid waste generated in Kuwait. It is also responsible for managing and operating the landfill sites. The required work is conducted through contractors under the supervision of the Municipality staff. The lack of material recovery facilities (MRFs) poses a problem to KM. It has taken into account the recommendations of KISR/Italian conducted workshops of recent years (2016,

2017 & 2018) and sub-contracted recently private companies to segregate recylables before SW disposal. The concerned units are under the Directorate for Environmental Affairs, which includes two Departments for Waste Treatment and Solid Waste Landfill. The responsibilities of the Directorate as stated in the website are as follows:

a. Work to verify the implementation of the strategy adopted by the municipality to manage waste and work on developing and improving it to improve its level in order to protect and preserve the environment.
b. Conduct studies related to waste management in terms of landfill sites and supervise the implementation of contracts related to waste management.
c. Verification of the technical methods used in the treatment of waste in all sites supervised by the Department of work related to waste management.
d. Work on developing the technical means used in the treatment of waste in all sites supervised by the Department of work related to waste management.
e. To work out the appropriate methods for waste disposal in accordance with the scientific principles applied in this regard.
f. To take all the executive procedures related to waste management, methods of treatment, utilization and disposal methods in coordination with all relevant concerned authorities.

In May 2018, KM commissioned the World Bank to conduct a project entitled "Kuwait Municipality (KM) Waste Management Planning Project" that addresses the MSW. The project budget is around KD 574,000 for a duration of two years. A working group was formed with representatives from KM, KEPA, Ministry of Finance, KISR, KU, Ministry of Education, and Ministry of Information. The project has the following components:

- Component 1 - Support on Municipal Waste Planning and Inputting to the National Waste Strategy*:* This task aims to organize and facilitate the planning process in KM , and in identifying the core elements of an interim Municipal Waste Action Plan which will address its municipal solid waste responsibilities within the framework of the Environment Protection Law, ensure the continuing development and improvement of the service

moving towards accepted international good practice with improved management of risks, and place the service on a more strategic footing for the longer term.

- Component 2 - Support in Developing a Community Engagement Strategy on Waste Management: This task aims to develop a comprehensive and integrated approach to community engagement related to MSWM for KM.
- Component 3 - Support the Development of Waste Information system: This task aims to support in developing an integrated waste information system for KM.

The project is in progress and is expected to be completed in 2020. The World Bank is seeking support and consultations from international consulting firms to execute the project.

Ministry of Public Works (MPW)

MPW plays an important role related to solid waste in the country that span different directions:

1. Responsibility for the sewage water network, hence, it can set and impose guidelines for the quality of sewage water generated from health care facilities and other commercial enterprises to ensure better quality sludge produced at the wastewater treatment facilities
2. Wastewater treatment and the quality of the sludge produced
3. Disposal of sludge, but it does not have currently an appropriate route for disposal; hence, the sludge is being disposed of at landfills, although it has the potential of being used as fertilizer and soil modifier for greening.
4. The generation of construction and demolition solid waste from public facilities
5. Setting up the specifications for materials and products that are used for public construction works, which currently favors the use of virgin materials over recycled materials.

Public Authority for Industry (PAI)

The PAI is the authority in charge of three important activities that are related to solid waste:

1. Kuwait Standards and Specifications, which regulates both imported materials as well as setting standards for recycled materials and their usage. Accordingly, Ministry of Trade and Industry is imposing ban on certain material and is emphasizing eco-labelling on imported goods.
2. Monitoring the proper handling and disposal of all industrial waste including solid industrial waste.
3. Authorizing and issuing licenses for recycling industrial projects, and allocating lands in industrial areas, if the factory is located outside landfill areas.

Industrial Bank of Kuwait (IBK)

IBK plays an important role in supporting solutions that can lead to the reduction of the solid waste. These include:

1. Providing loans to private sector waste recycling and conversion industrial enterprises
2. Provide vital data and information concerning the performance of the recycling industry

The interest of the bank is reflected by the study that was conducted in 2010 (IBK, 2010)

Kuwait Petroleum Corporation and Affiliated Companies

Kuwait Petroleum Corporation and its affiliated companies handles all of their waste. Most of the waste generated by the companies is industrial waste, which is handled by the HSE Departments within each company. KOC has its own waste management system that covers all waste generated from the sites that are under the jurisdiction of KOC, which covers a wide area within the country. The management system covers both hazardous and non-hazardous waste. For the non-hazardous waste, KOC collects the waste and keep track of the quantities of all waste generated and disposed of. According to KOC, the generated waste is categorized and segregated into recyclable and non-recyclables (Hazardous & Non-Hazardous) waste. The recyclable waste is carried out by segregating all the recyclable materials, which all are bailed and sent to recycling companies. The food waste is mixed with organic waste using a compost machine and the composite organic waste is being used as fertilizer (Al-Qallaf et al.,

2016). For the hazardous waste, the challenges are mostly associated with the solid waste that has some radiation.

Kuwait Institute for Scientific Research

KISR has three programs that addresses challenges related to solid waste These programs are:

1. The Environmental Pollution & Climate Program (EPCP) focuses on waste management research, valorisation and disposal. The research activities in the program have focused in recent years on various research aspects in this area which touches base on the energy sector and environmental management. The first of these areas is the mechanical treatment and product development from solid waste. The second is valorisation of solid waste of organic nature, in terms of product and energy recovery. The EPCP has also conducted environmental monitoring of landfill sites, sludge management and emission inventories related to waste management activities in Kuwait. In addition, good progress has already been made to establish dedicated laboratories, stations and pilot plant facilities under the "Waste Management Research Unit (WMRU)", that aims at supporting research related to solid waste recycling and final disposal. The WMRU include a dedicated laboratory for waste characterization that encompasses mechanical and thermal profiling units, in addition to, physical and chemical characterization. In addition, Pilot Plant Scale Facilities that support research related to fluidization, incineration, plastic solid waste processing, thermo-chemical treatment, and computer aided processes & simulation. In addition, a number of research projects have been completed including:

- Mechanical and Physical Evaluation of High Content Waste/Virgin Polyolefin Blends Exposed to Natural and Accelerated Weathering.
- Thermal and Morphological Study of Post Accelerated Weathering Virgin/Waste Polyolefin Blends.
- Investigating Biodegradable Bags Standards and Properties Under Kuwait's Environmental Conditions.
- Setting Up Technical Laboratory/Pilot Plant Protocols for Thermo-Chemical Treatment (TCT) Pyrolytic Practices.

- Collaborative research activities between EPCP and other KISR programs in studying Life Cycle Assessment (LCA) of feed production utilizing greenery and agricultural residues and their evaluation for livestock.
- International Collaboration with Italian Institutes and industries in WM activities, for organic and farm waste management at Kabd Area (Ongoing).
- International collaboration in development of industrial waste and spent catalysis operation, valorization and management of Kuwait by EPCP, London South Bank University, University College London, University of Birmingham and Campania University (Ongoing).
- Establishing Waste Management Research Unit (WMRU) P-KISR-06-11 (Ongoing).
- Solar Powered Fast Pyrolysis for Producing Bio-Oils from Municipal Solid Waste In The State Of Kuwait EM103C (Ongoing).

Moreover, over 25 on-job training for both KISR and professionals from KU, K-Companies and other parties, were offered since 2015. Furthermore, four technical workshops and forums were organized between the years 2016 to date (Al-Salem, 2017; 2018; Al-Salem and Sultan 2019). In addition, a number of specialized short courses were organized and delivered including:

- Plastics & the Environment (3 times offered since 2014)
- Energy Recovery from Plastic Solid Waste (PSW)
- Go Green Initiative Project - Citizen Science & Waste Management
- Plastics Degradation & Recycling
- Over fifteen (15) public lectures for waste management and awareness since 2015

For agricultural waste, the Desert Agriculture and Ecosystems Program focuses on various techniques and research on valuable byproducts from composting of agricultural wastes which include poultry waste, plant wastes, animal mortality wastes, yard wastes, etc. A number of projects have been conducted and successfully completed in association with KFAS under this umbrella such as:

- Formulation and Standardization of Plant Growth Media Using Indigenous Materials
- Composting Poultry Waste
- Dead Animal Disposal (Sheep) (On-going)

- Development of Nutritional and Biodegradable product to Improve Stability and Fertility of Sandy Soil (On-going)
- Investigating the adaptation of composting technology for horse manure in Kuwait (On-going)
- Composting Agricultural Waste Including Animal Mortalities planned with PAAFR

The Energy & Building Research Centre (EBRC) through its Construction and Building Materials Program focus part of its activities on waste building material. This line of work has been active for over 20 years. The following is a list of projects that reflects the efforts that is being made by the researchers associated with this program:

- Sustainable Use of Reclaimed Concrete Aggregates in Asphalt Pavements
- Surface Enhancement of Recycled Concrete Aggregates by the Removal of Attached Mortar Approach
- Engineering Characterization of Microfines in Local Sand
- Production and Characterization of Synthetic Ceramic Lightweight Aggregates Utilizing Kuwaiti Argillaceous Materials
- Suitability of Coarse Recycled Aggregates from Construction Waste in Producing Interlocking Concrete Paving Blocks (On-going)
- Applying Sulfur Concrete Technology to Produce Precast Concrete Units in Kuwait
- Utilization Of Sulphur Extended Asphalt (Thiopave) to Improve Asphalt Paving Mixtures in Kuwait
- Environmental Impact of Unsafe Disposal of Oil Based Mud Cuttings Generated from Oil Well Drilling
- Assessment of Current Construction Demolition Procedures
- Utilization of Fly Ash Based Compound for Containment of Oil Contaminated Soils
- Utilization of Waste Tires in Pavement of Rubberized Asphalt Roads (On-going)

The research is this area has resulted into a patented process for using multiple streams of waste material to produce light weight aggregate. It also led to the field application of some of the developed technologies.

Kuwait University

A number of Kuwait University faculty has been involved in researching solid waste and have published numerous papers related to the subject. Most of the research is related to monitoring and modelling.

Kuwait Foundation for the Advancement of Sciences

KFAS have been involved in supporting and funding research projects related to solid waste. Most of these activities are aligned with the Environmental Program, which KFAS supports. A list of these projects is shown in Table 6.

Kuwait Environment Protection Association

The society can play an important role concerning solid waste but currently has no related activities.

Table 6. List of Research Projects on Solid Waste Funded by KFAS

Project Code	Affiliation (EN)	English Project Title	Project Status
1992-1401-05	KISR	Study of the Environmental Pollution from Landfill Sites Receiving Wastes Generated During Iraqi Invasion	Completed
1998-1508-04	Kuwait Municipality (KM)	Municipal Solid Waste Management in Kuwait - Assessment of Municipal Solid Waste Collection and Transportation	Completed
1980-1207-08	KISR	Utilization of Cardboard and Poultry Waste from Municipal Solid Waste and Poultry Farms as Animal Feed	Completed
2008-1508-01	Industrial Bank of Kuwait (IBK)	The Economic Utilization of Waste in the State of Kuwait	Completed
P215-44EC-01	KISR	Mechanical and Physical Evaluation of High Content Waste/Virgin Polyolefin Blends Exposed to Natural and Accelerated Weathering	Completed

PN18-15EV-05	Kuwait University (KU)	Utilization of Dates Seeds as Waste Material in The Treatment of Wastewaters	Ongoing
PN18-14SC-04	KISR	Pyrolysis of reclaimed plastic solid waste from a landfill site in Kuwait	Completed

5.Current Status of Solid Waste Treatment in Kuwait

The majority of solid waste ends up in landfills. However, a relatively small percentage, which is not well-defined ends up recovered or recycled. The following is a briefing of the current solid waste treatment in the country.

Waste export

Currently, a small percentage of plastic waste materials of all types are being collected and exported to other Arab countries, such as Lebanon, Jordan and Egypt (Koushki et al., 2004). The quantities exported vary with market price and the environmental laws imposed in both Kuwait and the importing countries. Most collection is done by scavengers working either at origin or at landfills.

Incinerators and treatment

There are three facilities that are already established in this category. No details are available on these facilities in the public domain. These facilities are:

- Shuaiba Medical Incinerator. According to Al-Fares (2013), this incinerator is located in Mina Abdullah Industrial Area and operated by Ministry of Health. It receives medical waste from public and private hospitals. The waste is incinerated, and the bottom ash and fly ash are removed, temporarily stored in the facility, then transported and disposed off at the industrial sanitary waste landfill located in Shuaiba.
- Electrical Power Station at Al-Qurain Landfill BLF (BLF محطة توليد الطاقه الكهربائية في مردم القرين)
- Leachate Water Treatment Station (,محطة معالجة المياه الراشحة) also located at Al-Qurain

Recycling establishments in Kuwait

The number of establishments for waste recycling in Kuwait has been growing. The Ministry of Trade and Industry has a list of 33 companies registered as establishments for processing and recycling solid waste; however, it appears that most of the companies listed do not have recycling facilities. Hence, they are probably either inactive or are involved in trading with solid waste. KEPA has also a list of 26 companies, which presumably are involved in some activities related to waste recycling, collection or exporting. Table 7 provide a list of these companies, their contact details and their areas of specialization. The number of companies that are specialized in the main categories of solid waste are as follows:

Rubber Tyres:	1 Company
Plastic Recycling:	6 companies
Paper/Corrugated Cardboard:	5 companies
Construction/Demolition:	2 companies
Glass:	1 Company

It should be noted that some of these companies may not be active. Furthermore, actual information on plant capacity and the amounts of recycled solid waste is not readily available. Overall, the amount of waste which is being recycled is only a small fraction of total waste generated. It is also perhaps important to highlight some of the conclusions that the IBK (2010) study concerning waste recycling. The study estimates that 39% of MSW is recyclable, and the size of recycling business in 2008 is estimated at KD 25-40 million. Table 8, which was extracted from the IBK report provides estimates of the recyclable potential and actual recycling in 2008/2009.

Table 7. Industrial Installation for Municipal Solid Waste Recycling (Source: https://epa.org.kw/RecycleFactory))

م	Factory Name اسم المصنع	Type of Activity نشاط المصنع في إعادة التدوير	Address العنوان	email الموقع/الايميل الالكتروني	Telephone الهواتف
01	مصنع جرين ربر لإعادة التدوير	اعادة تدوير اطارات السيارات	أمغرة ق 2 قسيمة 17	www.grrcq8.com	24562699 24562799 69300229
02	Kuwaiti British Factory مصنع الكويتي البريطاني	اعادة تدوير الاحبار	الري	www.ekbf.com	24718801/2
03	شركة الوزان التجارية	اعادة تدوير الاخشاب	أمغرة (التوسعة الشرقية)	www.alwazzanregional.com	55966766
04	مصنع الكويت لتدوير البطاريات المستعملة	إعادة تدوير البطاريات المستعملة	أمغرة (التوسعة الشرقية) ق 3 قسائم 168-166-164	jkfbr@bydua.com jawed@bydaa.com jawwedyaqub@gmail.com	24584070 66070010 99069237
05	مصنع بن سليم البيئي للتدوير (دار مائدتي)	اعادة تدوير البطاريات والسيارات والبلاستيك والالمنيوم والزجاج	أمغرة ق 4 قسائم 60-62-64	www.binsaleem.com	24563477 99062567
06	Metal Recycling Company (MRC) شركة المعادن والصناعات التحويلية	إعادة تدوير البلاستيك	أمغرة ق 13 قسيمة 800024	mrcinfo@mrc.com.kw	24577773/4
07	شركة بيئتنا لإعادة التدوير	إعادة تدوير البلاستيك	أمغرة	www.beatouna.com abdelghani@alarfaj-group.com	24613980 99339180
08	مصنع أوتاد لإعادة تدوير البلاستيك	إعادة تدوير البلاستيك	أمغرة (التوسعة الشرقية) ق 3 قسيمة 80	Nadia-malallah@hotmail.com	99010929
09	مصنع الشرقية لإنتاج البلاستيك وإعادة تدوير النفايات البلاستيكية	إعادة تدوير البلاستيك	أمغرة (التوسعة الشرقية) ق 3 قسيمة 178	www.alsharqiyaplastic.com	50544383 99641101
10	شركة السور العالي للتجارة العامة والمقاولات	إعادة تدوير البلاستيك	أمغرة (التوسعة الشرقية) ق 3 قسيمة 169	High_fence@hotmail.com	99034999

11	شركة أمنية	إعادة تدوير قنينة الماء البلاستيكية	الجهراء – مخازن أجيليتي	www.omniya-kw.com	99057789 66942345
12	Kuwaiti Company To Transport And Handling Of Waste الشركة الكويتية لنقل النفايات ومعالجتها	إعادة تدوير البلاستيك والورق	أمغرة ق 4 قسيمة 111-112	info@wastecollectionkwt.com	24820411 24583539
13	مصنع الكويتية المتحدة لمعالجة وتكرير الزيوت	إعادة تدوير الزيوت	الشويخ الصناعية ق 3ب شارع 53 5 قسيمة	www.alwessam-int.com a.algaradi@alwessam-int.com	24343562/4
14	مصنع مزج لتكرير الزيوت	إعادة تدوير الزيوت	الشويخ الصناعية ق 3ب شارع 57 14 قسيمة	vermadkl@kentzgroup.com vermadkl@gmail.com	22433705
15	شركة الخليج المتطورة للأنظمة البيئية	إعادة تدوير الزيوت المستعملة والمخلفات الكيميائية	الشعيبة الغربية ق 5 قسائم 100- 102- 99 -101ZB - 103B	info@envosyskw.com	22271591
16	الشركة الكويتية لإنتاج الزيوت والشحوم	إعادة تدوير الزيوت والشحوم	الشعيبة ق 4 قسيمة 52	www.kuwaitlube.com	23261247/9 18333336
17	Environment Preservation Industrial Company (EPIC) الشركة الصناعية لحماية البيئة	إعادة تدوير المخلفات الانشائية	الدائري السابع قرب مردم كبد	www.epickw.com	22200033 97142333
18	الشركة العربية الدولية للمشروعات الصناعيةAIIP	إعادة تدوير المخلفات الانشائية		www.aiipkw.com	22200444
19	Gulf Paper Manufacturing Co. شركة الخليج لصناعة الورق	إعادة تدوير الورق	الشعيبة الغربية ق 3 قسيمة 43	gpmc@gulfpaper.com.kw	23262072 23263704
20	مصنع الوطنية للمنتجات الورقية	إعادة تدوير الورق	صبحان	www.alwataniapaper.com	24742617
21	United Paper Industries Company الشركة المتحدة للصناعات الورقية	إعادة تدوير الورق	الشعيبة الغربية ق 2 قسيمة 75	www.Upi.com.kw	23260502
22	Carton Industries Company شركة صناعة الكرتون	Cardboard Boxes			
23	Gulf Glass Manufacturing Company شركة الخليج لصناعة الزجاج	Empty Glass Bottles			

24	Gulf Cable & Electrical Industries Company شركة الخليج للكابلات والصناعات الكهربائية	Production of Granules of Recycled Waste Cable			
25	National Color Ink Company الشركة الوطنية للاحبار	Refilling of Empty Printer Cartridges and Manufactuirng			
26	United Waste Management Company الشركة المتحدة لإدارة النفايات			https://www.united-wmc.com/index.htm	2291-3050 2291-3051

Table 8. Assessment of the likely range of theoretical waste recycling potential and estimation of actual recycling potential (IBK, 2010)

Type	Estimate of Potential (kton/year)	Estimate of % Recycled	Estimate of Realistic Recycling % Objective
Paper/Cardboard	400-500	~5-15% (~20-75,000 t/y)	30%
Textile	60-70	~5-10% (~3-7,000 t/y)	30%
Plastic	200-600	~10-15% (~20-90,000 t/y)	20%
Glass	40-50	~5-10% (~2-5,000 t/y)	40%
Metal (from MSW)	60-90	~15-20% (~9-18,000 t/y)	50%
Organic (food & Greenery	500-700	~0-5% (~0-35,000 t/y)	50% (compost)
Other Non-organic	70-100	~0-5% (~0-5,000 t/y)	
Car Tyres	1.5-2 milion tyres/y	~5-15% (~75-300,000 tyres/y)	80%
Car Body Scrap	100-150,000 cars/y	~10-30% (~10-45,000 cars/y)	95%
Car batteries	300-500,000 units/y	~10-30% (~30-150,000 units/y)	90%
e-Waste	3-10	~10-15% (~0.3-1.5 t/y)	50%

Research Efforts Post 1990 on Solid Waste

Since 1990, around 66 papers, books, chapter in books, patents and workshop presentations related to solid waste have been published. A list of these publications is found in Appendix 2. There are probably some publications that have been overlooked. The publications fall into the following subjects related to solid waste:

1. Solid waste survey by amount, main categories and sub-categories: 13 papers
2. Modelling: 2 papers
3. Management and recycling: 34
4. General & public awareness of solid waste problem: 7 papers
5. Environmental information system: 6 papers
6. Environmental impact of solid waste: 4 papers

6. Preliminary Comparison of Kuwait Waste Generation/Management with Other Countries

Table 9 shows a selection of developed and developing countries MSW generation rates (kg per capita per day). The rate of MSW generation is lower than USA and Canada, and comparable to most other countries. One tangible fact can be withdrawn from the estimates of MSW generation shown is that the more prosperous and well established a country is economically, the higher the generation rate is. And it is also worth noting that countries with a well-developed industrial scheme and infrastructure that can handle MSW will have less of a SW generation rate. The State of Kuwait can be noted to be the highest within countries of the MENA region as shown in Table 8. Lifestyle, urbanization and social behavioural aspects of nationals and expatriates alike make SW generation a concern in Kuwait. Organics (with a major share of household food items) are generated at a rapid rate with estimates showing its daily production rate as 142.6 tonnes. However, and compared to other countries, organics are noted to be in the range of many other developed and developing countries. It might even be lower than other Asian societies. On contrast, plastic solid waste (PSW) generated from municipal sources encompassing households and commercial ones, represents a higher fraction of the world's average total waste load (10%) which is estimated in Kuwait to be over 18% in some studies (Al-Jarallah and Aleisa, 2014). Other MSW fractions are produced at a rate of some 165 tonnes per day, with an estimated waste from electrical and electronics equipment (WEEE) generation rate of about 17 kilograms per person per annum. This is considered as an added component to plastic waste in Kuwait not part of the MSW stream. These estimates are all on the increase, where past PSW generation rates shows that Kuwait produced only 150 ktpa back in 2001 (Al-Meshan and Mahros, 2001), and 200 ktpa in 2015 (Al-Salem et al., 2015).

The World Bank provided a comprehensive report recently that describes the status of solid waste in the world and projection till 2050 (Kaza et al., 2018). Kuwait is classified in the report as one of the high-income countries. The waste disposal in this category of countries vs other categories is shown in Figure 8. According to the figure around 40% of the solid waste end in open dump and landfills. Obviously based on current waste disposal practices, Kuwait

performance is significantly below the levels of performance of other high-income countries, and is closer to the performance of low-income countries

Table 9. Collection of Municipal Solid Waste Generation Rates In Developed and Developing Countries. Source: Al-Salem (2019).

Country	Total Generated MSW (Kg Per Capita Per Day)	Composition (%)				
		Organics	Plastics	Paper	Metal	Other
Algeria	1.21	70	10	5	5	39
Argentina	1.22	40	14	24	2	20
Bahrain	1.10	N/A				
Belgium	1.33	39	5	17	3	36
Brazil	1.03	61	15	15	2	7
Canada	2.33	24	3	47	13	14
Czech Republic	1.10	18	4	8	2	67
Egypt	1.37	60	12	10	-	-
Germany	2.11	14	22	34	5	24
Italy	2.23	29	5	28	2	35
Lebanon	1.18	63	7	18	3	9
New Zealand	3.68	56	8	21	7	8
Saudi Arabia	1.30	N/A				
Qatar	1.33	N/A				
Syria	1.37	65	12	10	2	11
Turkey	1.77	65	14	7	6	7-24
United States	2.58	25	12	34	8	21
Kuwait	1.40	46	18	7	4	25

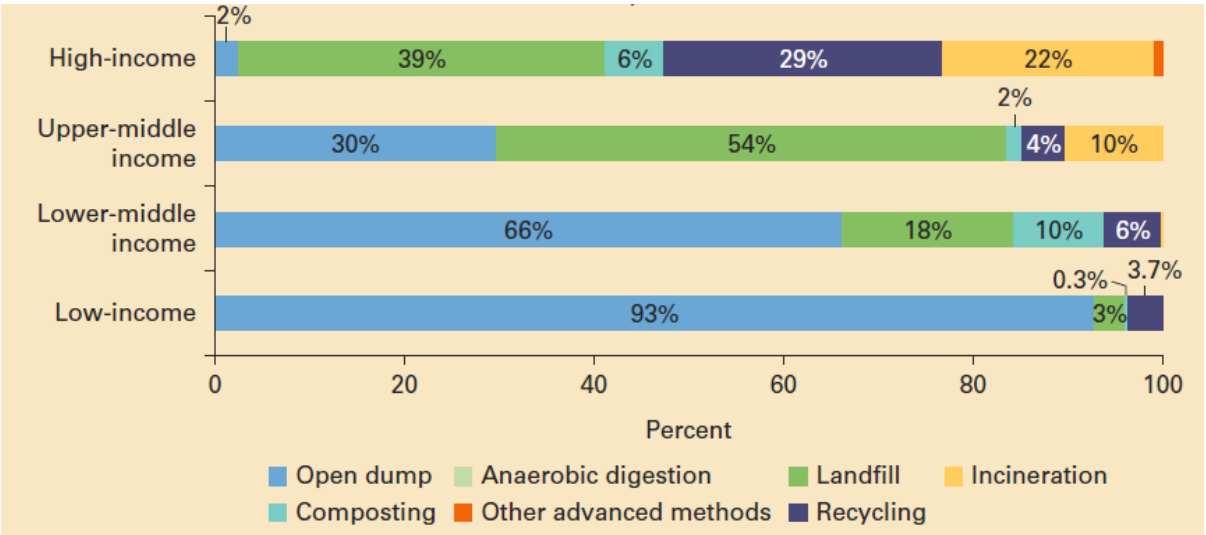

Figure 8. Disposal methods of different countries by income.

7. Strategic value and benefits to Kuwait

Relevance to KFAS strategic plan

KFAS strategy 2017/2021 listed environment as one of the national priority areas of research that KFAS is planning to support. There are numerous environmental issues that are important to the country. KFAS has emphasised waste management as one of the three main research priorities as of recent years. However, taking into consideration the challenges related to solid waste that the country is facing as presented in this report, it appears that the development of a scientific and technical agenda that addresses these challenges is in conformity with KFAS Mission as defined in its strategy, namely ***"Stimulate and catalyse the advancement of STI for the benefit of society, research, and enterprise in Kuwait."*** The development of effective solutions to the problems associated with solid waste will have a strong impact on all segments of Kuwaiti society.

Relevance to sustainability, economic development and quality of life in Kuwait

This report clearly identified the solid waste problem as one of the national priorities that should be addressed by the Kuwaiti society. As indicated in the introductory sections of this document, the solid waste is leading to serious land degradation taking into consideration the limited availability of land for urban expansion. It is also impacting the environment of the country through the emissions that are produced from landfills. They are also potential source

for pollution to the limited underground water resources available in the country. Furthermore, landfills will potentially impact the health of the residents in nearby residential areas. Finally, solid waste is an economic loss of resources that can potentially be recycled or transformed into useful products, such as gravel, aggregates and fuels.

While solid waste is a global problem, the nature of solutions that are required to be adopted by each country, or even each community, depends largely on the specific constraints that the community has. Hence, solutions cannot be simply imported and adopted. They require to be adapted, and perhaps new creative technologies may need to be developed. Furthermore, it is very important that when solutions are adopted, both economic and environmental considerations should be taken into account.

The constraints in Kuwait concerning the approach to solve the solid waste problem are perhaps among the stringiest worldwide. The land is restricted, the water resources are scarce, and the available resources to support sustainability are limited. Hence, adopting a long-term goal of zero-solid waste seems to be inevitable.

8. Roadmap for moving forward

Gap analysis

Based on the information presented in this report on the status of solid waste in the country, a number of technical and scientific gaps were identified, which are negatively impacting the progress towards the development of cost-effective solutions to the solid waste problem in the country. However, it appears that both KEPA and KM are already addressing some aspects of these gaps. Table 10 presents these gaps as well as an assessment of whether an intervention is already in progress or further work is required.

Table 10. Technical and Scientific Gaps of the Solid Waste Problem in Kuwait

Identified Gap	Comment
a. **Waste Management Philosophy.** The main gap is the lack of a solid waste management philosophy that is based on benchmarking with other developed and high-income countries,	This gap is apparently being addressed by KEPA through the project, which is

	and outputs of applied research. Although, KEPA is working on developing the national solid waste strategy, however, extensive research work is required from all S&T institutions in the country to support KEPA in developing a strategy that incorporates sustainable solutions covering the needs of the country.	currently being conducted with Fraunhofer, and will lead to the development of a long term strategy. Hence, KFAS is not expected to have a role
b.	**Quantification of Solid Waste.** While waste composition is generally not very critical for MSW, since the composition is very similar across countries, but the composition differs significantly for C&MSW and industrial waste. Nevertheless, and despite the efforts that has been made over the past 20 years concerning the solid waste in the country, the data is not adequate to permit the development of a detailed plan to address the problem. KEPA has already initiated a systematic effort to generate the required data. Further support is required from all stakeholders to address the following issues: – The amounts, types of waste, and suitability of waste in closed and open landfills, including data on WEEE, which is a growing problem – The variation of solid waste generated from different communities within the country to develop improved forecasting of solid waste generation taking into account area, societal and economic data and regression analysis	This gap is being addressed by KEPA through the project, which is currently being conducted with Fraunhofer. It is also apparently being addressed by KM in its project with the World Bank
c.	**Setting up standards that leads to solid waste reduction**. In most high income countries, efforts are being made to reduce the waste by adopting standards for products that can effectively reduce the amount of waste generation. The following gaps currently exists: – Standards for alternative plastics material for multiple use, and for fast bio-degradation – Standards for more durable tyres – Standards for more durable building material	It does not seem that this gap is currently being addressed by the stakeholders, and further research is required.

d. **The socio-economic impact of current practices of solid waste disposal.** Despite the general perception that solid waste is a growing problem in the country, the exact long term socio-economic impact of the problem is not well defined. The specific issues that need to be addressed include: – The impact on Kuwait development, sustainability and environmental performance taking into consideration various international agreements – The effect of current disposal practices on Kuwait Municipality plans for land utilization – The long term health impact of current solid waste disposal methods – The real cost on the society and the government of current waste disposal practices	It does not seem that this gap is currently being addressed by the stakeholders, and further research is required.
e. **Public awareness.** The public awareness of solid waste problem is not adequately addressed. There is prospect to reduce the size of the problem through changes of social behaviour and attitude, emphasizing waste reduction and re-use. The current gaps that exist include: – Identification of the most effective public awareness methods that should be adopted – A long term plan that can effectively lead to changes in behaviour	Almost no publications are available. KM through its project with the World Bank will apparently work on this issue. However, additional work may be required.
f. **Collection and segregation of solid waste practices.** The current methods used in collecting solid waste are conventional methods. Methods used in other high income countries needs to be reviewed and analyzed to identify potential better practices. The key issues that need to be addressed are: – Novel methods of collection and segregation that are tailored to Kuwait constraints	It does not seem that this gap is currently being addressed by the stakeholders, and further research is required.

– Assessment of potential of the required technologies to reduce the risks of some solid waste at source, e.g. the wastewater from hospitals, which is currently directed to wastewater treatment plants and results in having the generated sludge being disposed of in landfills rather than recycled, despite its good potential as a material for sandy soil treatment (Appendix 3).	
g. **The solid waste recycling industry and its potential for growth**. The solid waste recycling industry is still limited, and its capacity is much lower than the rate of waste generation. The main gaps are the following: – Identifying the best approach for treatment and reduction of organic solid waste. Currently, most developed countries are reducing organic solid waste through thermal conversion (pyrolysis) converting it to fuels. For Kuwait to adopt this approach, pilot plant and semi-industrial scale data are required to define the costs associated with applying relevant technologies in the country – An assessment of the current recycling companies aimed at identifying the problems that the industry is currently facing – Identification of new industries and technologies that can potentially be applicable to Kuwait and the development or the adaptation of technologies for recycling that better suits Kuwaiti constraints – The development of new products from raw materials that can be generated through solid waste recycling – Optimizing the cost of production of current recycling industrial enterprises – Working towards the development of a consortium of all stakeholders pilot plants that aim at developing appropriate technologies that best suit the country	It does not seem that this gap is currently being addressed by the stakeholders, and further research is required.

h. **The legislative and legal framework and its adequacy in addressing the solid waste problem.** The handling of the solid waste in the country was initially the responsibility of Kuwait Municipality. While KM still carries a major responsibility for collection and ownership of landfill sites, KEPA is playing a greater role as specified in its new law. Some of the gaps that are identified include: – Assessment of overlap of responsibilities between different stakeholders and streamlining the procedures to support fast decision making – Identification of factors that are hindering the implementation of Articles 30, 31, 33, and 39 – Protocols and regulations to certify contractors for building demolition and solid waste collection, which ensures that their practices do not aggravate the problem. For example, current practices of demolition contractors lead to high percentage of C&DSW fines when metals are extracted, which can be avoided. – Development of standards for recycled products that suits certain applications in the country – Development of regulations to support the usage of recycled solid waste products. – Other legislations and regulations include technical issues, such as: • Banning/ support of certain materials • New technologies waste to energy • Concepts f circular economy • Cradle to Cradle	It does not seem that this gap is currently being addressed by the stakeholders, and further research is required.

Outline of the potential actions needed to solve the solid waste problem

Taking into consideration the active roles that KEPA and KM are assuming to address the solid waste problem in the country and the projects that are currently in progress with

Fraunhofer UNSICHT and the World Bank, KFAS can play an important but a limited role to accelerate the progress towards resolving the problems associated with the solid waste problem in the country. The proposed interventions are summarized in Table 11, and are aligned with KFAS Strategy 2017/2021. The potential stakeholders with whom KFAS is proposed to collaborate are also listed for each intervention. KFAS will partner with KISR, KU, Private Universities, and other public and private institutions in implementing the proposed interventions. Table 12 lists also a number of low hanging fruit projects that will yield results in the near future. The focus of KFAS support should be on projects that will:

(i) solve the problem in the near future with tangible results,

(ii) create a green image for KFAS within the next three years, and

(iii) lead to tangible results that various stakeholders and clients can relate to.

The suggested projects revolve around valorising the SW component of Kuwait with new market development and product development opportunities, whilst reducing the accumulation and generation of SW. A clear emphasis should be given on product recovery encompassing fuel and energy from MSW as a main thrust for Kuwait, whilst reducing both generated and accumulated waste. The emphasis should be given to waste dealt with by consumers on a daily basis namely the major share of MSW (Food, plastics, organics, etc)/agricultural waste, and C&DSW. The suggested projects should also complement KEPA, KM, and other stakeholders' efforts to address the problem.

Table 11. Proposed Interventions by KFAS to Address the Solid Waste Problem in Kuwait

Proposed Action	Targeted Gap	Collaboration with Other Stakeholders
1. Research Support under Program 1 Thrust Area 2. The Research Directorate will stress the topics related to solid waste in future "Call for	Setting up standards that leads to solid waste reduction.	Public Authority for Industry and Ministry of Trade and Industry.
	The socio-economic impact of current	KEPA and KM

Proposals" to direct researchers in Kuwaiti institutions to address relevant problems	practices of solid waste disposal.	
	Collection and segregation of solid waste practices.	KEPA and KM
	The legislative and legal framework and its adequacy in addressing the solid waste problem.	KEPA, KM, and Public Authority for Industry.
2. Technical and research support under Program 3 Thrust Area 3. The Innovation and Enterprize Directorate will direct efforts towards the needs of local recycling industries and will develop an awareness seminar program targeted towards this industry.	The solid waste recycling industry and its potential for growth.	Selected local recycling industrial establishments, the Public Authority for Industry, Kuwait Industrial Bank, and the National Fund for Small and Medium Enterprises.
3. KFAS affiliate, the Advancement of Science Publishing and Distribution Company will issue publications aimed at different categories of the society	Public awareness: all segments of the society.	KEPA and KM
4. KFAS affiliate, the Kuwait Scientific Center will include exhibition programs and events related to the waste solid problem	Public awareness: all segments of the society.	
5. KFAS affiliate, the Sabah Al-Ahmad Center for Giftedness and Creativity will develop	Public awareness: youth and inventors	

programs aimed at solid waste problem		

Table 12. List of Low Hanging Fruit Research Topics to Address the Solid Waste Problem in Kuwait.

Sr. No.	Project title (theme)	Main objectives	Timeframe
Solid Waste Management			
1	Determining the composition and physio-chemical properties of waste generated in Kuwait	– Determining the composition of HHSW and commercial SW in Kuwait. – Data-banking properties and major parameters that influence the waste in Kuwait *This feeds into KEPA and KM strategy development	1-2 years
2	Benchmarking with international practices in support of KEPA effort to develop a national strategy	Developing general guidelines to support Kuwait waste solid strategy	1-2 years
3	Development of biodegradable polyolefin based bags standards for the state of Kuwait	Developing standards for plastics to ensure accelerated degradation under Kuwait ambient conditions	1 year
4	Development of biodegradable plastic products as a means for waste management and mitigation of associated impacts.	Comparing thermo-plastic starch and oxo-biodegradables in a Kuwaiti context, after developing the blends applicable for the state of Kuwait and optimising process conditions.	1-2 years
5	Development of an overview technical action plan for SW valorisation and management in Kuwait	Scenarios that incorporate industrial sector in managing and developing products from SW, whilst reducing environmental burdens	1.5 – 2 years

Municipal Solid Waste			
6	Micro and pilot scale **thermo-chemical treatment** for fuel recovery from ELTs in Kuwait	Determining potential and commissioning a pilot unit and semi-industrial unit for fuel recovery from ELTs	2-3 year(s)
7	Utility generation from **thermolysis** of PSW in Kuwait: Steam turbine commissioning	Electricity and heat recovery from the pyrolytic/gasification reaction of plastics	2 year(s)
8	Reclamation potential of operating landfill/disposal sites in Kuwait	Energy generation (**incineration**) potential and environmental assessment of landfill sites from the waste reclaimed in Kuwait. *This feeds into KM and world bank plans in Kuwait	1.5 year(s)
9	On the end of life tyres (ELTs) pyrolysis for chemicals recovery in multi-scale reactor setups	Establishing costs framework for tyres recycling	2-3 years
10	Determining the potential of energy recovery from fandfill sites in Kuwait	Establishing process and associate costs	2-3 years
11	Governing standards development for products from solid waste in Kuwait generated from the MSW stream	– Determining the properties and processes of valorising MSW. – Standards and testing protocols of waste products associated with recently developed plastic waste products in conjunction to paper waste management.	2-3 years
Construction and Demolition Waste			
12	Utilization of waste from concrete ready-mix plants in construction applications	Developing a technology for C&D recycling	1-2 years
13	C&D waste standards and protocols determination	The mechanical recycling potential of building SW and the	1 year

		development of its standards and markets in Kuwait	
14	Recycling of spent catalysts from Kuwait petrochemical industries for production of concrete for various engineering applications	Developing a process for recycling industrial waste	1-2 years
15	Utilization of biomedical waste ash in cement application	Developing a process for recycling medical waste	1 year
16	In-Situ pilot trials-immobilization of oil contaminated soils by fly ash based compound for use in construction materials	Developing a process for recycling contaminated soil	1 year
17	WEEE management standards in Kuwait by determining and testing thermal response properties	Determining life of the WEEE in Kuwait and understanding the potential of recyclability in various mechanical and thermal units	1-2 years
Agricultural Waste			
18	Dead animal disposal (sheep)	Developing guidelines	1 year
19	Selected food waste and agriculture waste product development	Utilizing potential of the **cook extrusion** technique in industry for Kuwait whilst developing a product from the food waste (e.g. date palm, date fruit).	1.5 year(s)
20	Development of nutritional and biodegradable product to improve stability and fertility of sandy soil	Developing a process and product through recycling agricultural waste	1-2 years
21	Investigating the adaptation of composting technology for horse manure in Kuwait	Adaptation of technology to Kuwait ambient conditions	1 year
22	Composting agricultural waste including animal mortalities	Developing a recycling process for agricultural waste	1-2 years
23	Wastewater sludge as a fertilizer and sandy soil modifier	An assessment of sludge produced by the wastewater treatment facilties for usage as fertilizer and soill modifier	1.5 years

9. Conclusions and Recommendations

This report is a draft document that aims at defining the seriousness of the problem of solid waste in Kuwait, and the actions and activities of various stakeholders to address these problems. The review clearly indicates that KEPA and KM are currently addressing the problem in a systematic way. In addition, researchers from both KISR and KU have been researching the subject of solid waste and numerous papers and reports have been published on the subject. Furthermore, KISR has already formulated research programs to address the solid waste problem. The capacity to conduct meaningful and effective research on the subject is already well developed. The report identified a diverse set of gaps that may still need to be addressed to ensure that Kuwait will be in the future on a sustainable path to reduce or even eliminate this problem. It is obvious that prioterizing and addressing these gaps require the cooperation of all stakeholders, including the industrial enterprises that are already engaged in waste recycling. KFAS can have an impactful role through interventions within its existing strategic programs. A list of proposed interventions for KFAS that can help in closing the technical and scientific gaps were identified.

It is recommended that KFAS continues its efforts in further developing this report and secure the acceptance and endorsement of the stakeholders in order to arrive to a meaningful agenda of research and other activities that can leave a tangible impact on society in resolving this problem. To achieve this objective, meetings are proposed to be organized with the stakeholders to have an in-depth discussion and assessment of the preliminarily identified gaps and the development of priority list of activities that can be supported by KFAS to complement the efforts of the stakeholders in reducing and mitigating the problem.

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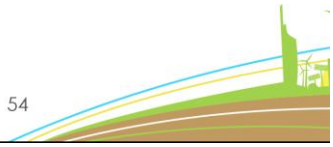
Appendix 1. Articles Relevant to Solid Waste in KEPA Law No. 42/2014 including Revisions 99/2015

(مـــادة 28)

يحظر الجمع والنقل والتخلص من النفايات البلدية الصلبة والخطرة ونفايات الرعاية الصحية والحمأة الناتجة عن مخلفات الصرف الصحي والصناعي بغير ترخيص من الجهات المعنية وتحدد اللائحة التنفيذية لهذا القانون إجراءات وشروط منح هذه التراخيص وآلية التداول والتعامل مع هذه المواد.



(مـــادة 29)

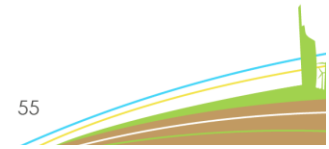
يجب التخلص من النفايات الخطرة والنفايات البلدية الصلبة ونفايات الرعاية الصحية والحمأة بأنواعها وفقاً للشروط والمعايير البيئية التي تحددها اللائحة التنفيذية لهذا القانون. كما يحظر التخلص من النفايات بأنواعها بالردم المباشر في مواقع غير مخصصة بيئياً.

(مـــادة 30)

يلزم التخلص من النفايات البلدية الصلبة وفقاً للشروط والمعايير البيئية التي تحددها اللائحة التنفيذية لهذا القانون. وتلتزم الجهات المعنية بانجاز واستكمال البنية التحتية لأعمال تدوير النفايات البلدية الصلبة خلال خمس سنوات بحد أقصى من تاريخ صدور هذا القانون.

(مـــادة 31)

تلتزم المصادر التي يتولد منها نفايات خطرة أو نفايات الرعاية الصحية أو الحمأة إضافة الى الجهات



المختصة والمكلفة بجمع ونقل والتخلص من النفايات بأنواعها بتزويد الهيئة بتفاصيل هذه النفايات مع الاحتفاظ بسجل خاص وتحدد اللائحة التنفيذية لهذا القانون البيانات المطلوبة وآلية نقلها وإدارتها.

(مـــادة 32)

يحظـر إلقـاء أو معالجـة أو حـرق النفايـات البلديـة الصلبة إلا في المرافق المخصصة لذلك ويراعى في ذلـك البعـد عـن التجمعـات البشـرية ومنـاطق الحساسـية البيئيـة ، وتحـدد اللائحـة التنفيذيـة لهـذا القانون المواصفات والضوابط الخاصة بهذه المرافق ومواقعها.

(مـــادة 33)

يحظر إلقاء القمامة أو المخلفات أياً كان نوعها إلا في الحاويات المخصصة لذلك.

(مادة 34)

تعنى الهيئة بالتنسيق مع الجهات المختصة بإعداد البرنامج الوطني للإدارة المتكاملة للمخلفات

شاملا إعداد وتطوير وتحديث إستراتيجية وطنية للإدارة المتكاملة للنفايات البلدية الصلبة والنفايات الطبية والسائلة والنفايات الخطرة مشفوعة بخطط العمل ومسؤوليات مؤسسات الدولة وبرامج الرقابة والرصد والبرامج الزمنية لتنفيذها. وتلتزم الهيئة بعرض البرنامج على المجلس الأعلى لاعتماده خلال ثلاثة أعوام كحد أقصى من صدور هذا القانون.

(مـــادة 35)

يمنع ربط المخلفات السائلة الصحية والصناعية للمناطق الصناعية مع الشبكات العامة للأمطار ومخلفات الصرف الصحي وتلتزم الجهات المختصة بإنشاء محطات خاصة بهذه المناطق خلال سبع سنوات بحد أقصى من تاريخ صدور هذا القانون.

(مـــادة 36)

يمنع إقامة مرادم جديدة للنفايات بدولة الكويت أو توسعة القائم منها إلا بموافقة المجلس الأعلى

وفي كل الأحوال يلزم إقامة دراسات المردود البيئي كما يلزم عند إقامتها أو التوسع فيها الالتزام بالشروط التي تبينها اللائحة التنفيذية لهذا القانون. وتلتزم الجهات المعنية بوضع خطة تفصيلية لإدارة وتقييم ومعالجة واسترجاع كافة المرادم بالبلاد خلال سنة من تاريخ صدور هذا القانون على ان تعرض على المجلس الأعلى لاعتمادها.

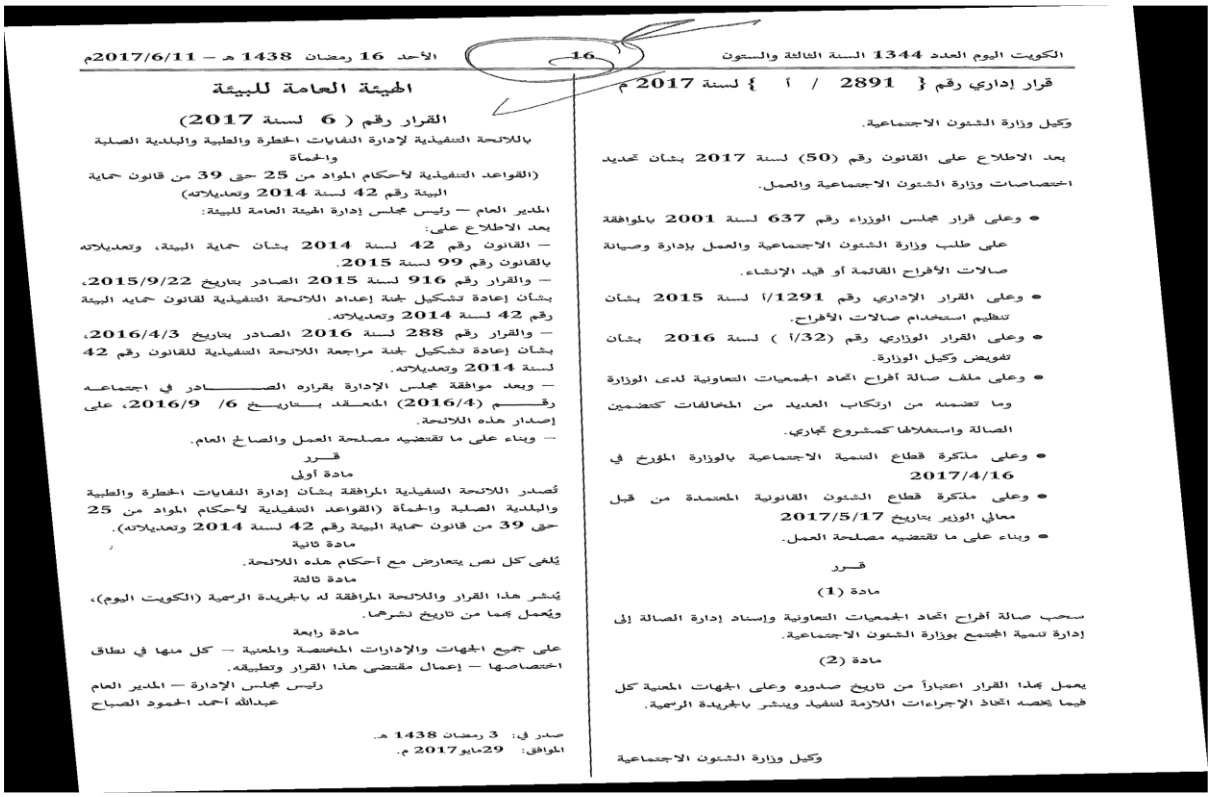
(مادة 37)

تلتزم الجهات المعنية خلال خمس سنوات من تاريخ صدور هذا القانون بالحصر الكامل لأنواع وكميات ومواقع تواجد المخلفات الاسبستية بالبلاد كما تلتزم بالتخلص من هذه المخلفات الخطرة في موقع مؤهل لذلك وتتكفل الدولة بالالتزامات المالية المترتبة على عمليات الجمع والنقل والتخلص من هذه المخلفات من السكن الخاص والمنشآت الحكومية.

(مادة 39)

تلتزم الجهات المعنية بوضع المواصفات القياسية لكافة المواد المعاد تدويرها وطبيعة ونوعية وآليات استخدامها بما يحقق السلامة والكفاءة من الاستخدام، كما تعمل الدولة على منح المواد المعاد تدويرها داخل إقليم الدولة والمتوافقة مع المواصفات القياسية الأفضلية في مشاريعها دعماً لصناعات التدوير.

KEPA By law of the year 2016 for WM strategies and standards



الكويت اليوم العدد 1344 السنة الثالثة والستون — 16 — الأحد 16 رمضان 1438 هـ – 2017/6/11م

قرار إداري رقم { 2891 / أ } لسنة 2017 م

وكيل وزارة الشئون الاجتماعية.

بعد الاطلاع على القانون رقم (50) لسنة 2017 بشأن تحديد اختصاصات وزارة الشئون الاجتماعية والعمل.

- وعلى قرار مجلس الوزراء رقم 637 لسنة 2001 بالموافقة على طلب وزارة الشئون الاجتماعية والعمل بإدارة وصيانة صالات الأفراح القائمة أو قيد الإنشاء.
- وعلى القرار الإداري رقم 1291/أ لسنة 2015 بشأن تنظيم استخدام صالات الأفراح.
- وعلى القرار الوزاري رقم (32/ أ) لسنة 2016 بشأن تفويض وكيل الوزارة.
- وعلى ملف صالة أفراح اتحاد الجمعيات التعاونية لدى الوزارة وما تضمنه من ارتكاب العديد من المخالفات كتضمين الصالة واستغلالها كمشروع تجاري.
- وعلى مذكرة قطاع التنمية الاجتماعية بالوزارة المؤرخ في 2017/4/16
- وعلى مذكرة قطاع الشئون القانونية المعتمدة من قبل معالي الوزير بتاريخ 2017/5/17
- وبناء على ما تقتضيه مصلحة العمل.

قـــرر

مادة (1)

سحب صالة أفراح اتحاد الجمعيات التعاونية وإسناد إدارة الصالة إلى إدارة تنمية المجتمع بوزارة الشئون الاجتماعية.

مادة (2)

يعمل بهذا القرار اعتباراً من تاريخ صدوره وعلى الجهات المعنية كل فيما يخصه اتخاذ الإجراءات اللازمة لتنفيذ وينشر بالجريدة الرسمية.

وكيل وزارة الشئون الاجتماعية

الهيئة العامة للبيئة

القرار رقم (6 لسنة 2017)

باللائحة التنفيذية لإدارة النفايات الخطرة والطبية والبلدية الصلبة والخماة

(القواعد التنفيذية لأحكام المواد من 25 حتى 39 من قانون حماية البيئة رقم 42 لسنة 2014 وتعديلاته)

المدير العام — رئيس مجلس إدارة الهيئة العامة للبيئة:

بعد الاطلاع على:

— القانون رقم 42 لسنة 2014 بشأن حماية البيئة، وتعديلاته بالقانون رقم 99 لسنة 2015.

— والقرار رقم 916 لسنة 2015 الصادر بتاريخ 2015/9/22، بشأن إعادة تشكيل لجنة إعداد اللائحة التنفيذية لقانون حمايه البيئة رقم 42 لسنة 2014 وتعديلاته.

— والقرار رقم 288 لسنة 2016 الصادر بتاريخ 2016/4/3، بشأن إعادة تشكيل لجنة مراجعة اللائحة التنفيذية للقانون رقم 42 لسنة 2014 وتعديلاته.

— وبعد موافقة مجلس الإدارة بقراره الصـــــادر في اجتماعه رقـــم (2016/4) المنعـقد بـتاريـخ 6/ 2016/9، على إصدار هذه اللائحة.

— وبناء على ما تقتضيه مصلحة العمل والصالح العام.

قـــرر

مادة أولى

تُصدر اللائحة التنفيذية المرافقة بشأن إدارة النفايات الخطرة والطبية والبلدية الصلبة والخماة (القواعد التنفيذية لأحكام المواد من 25 حتى 39 من قانون حماية البيئة رقم 42 لسنة 2014 وتعديلاته).

مادة ثانية

يُلغى كل نص يتعارض مع أحكام هذه اللائحة.

مادة ثالثة

يُنشر هذا القرار واللائحة المرافقة له بالجريدة الرسمية (الكويت اليوم)، ويُعمل بهما من تاريخ نشرهما.

مادة رابعة

على جميع الجهات والإدارات المختصة والمعنية — كل منها في نطاق اختصاصها — إعمال مقتضى هذا القرار وتطبيقه.

رئيس مجلس الإدارة — المدير العام

عبدالله أحمد الحمود الصباح

صدر في: 3 رمضان 1438 هـ.

الموافق: 29مايو2017 م.

الفرع الثاني

الأحكام التنفيذية لنص المادة 26 من القانون

(النفايات المشعة منخفضة الإشعاع)

"يحظر تداول النفايات المشعة منخفضة الإشعاع المولدة من المستشفيات أو بعض الصناعات بغير ترخيص مسبق من الجهات المعنية، ويجب التخلص من هذه النفايات وفقاً للشروط والمعايير البيئية التي تحددها اللائحة التنفيذية".

النظم والإشتراطات والمعايير

أولا: تصنيف النفايات المشعة

(مادة 3)

تتمثل أصناف النفايات المشعة فيما يلي:

1. مواد أو نفايات معفاة:

المواد المحتوية على مستويات من النظائر المشعة بتركيزات تقل عن تلك التركيزات الواردة في الجدول 1 إلى 3 من القرار الوزاري رقم 2003/553.

2. نفايات منخفضة المستوى قصيرة العمر النصفي/ نفايات اضمحلال:

النفايات المشعة منخفضة المستوى، المحتوية على نظائر مشعة قصيرة العمر النصف دون غيره، أي النظائر المشعة التي يقل عمرها النصفي عن مئة يوم (100) يوم، والتي تضمحل حتى مستويات الحدود المسموحة في غضون ثلاث (3) سنوات من تاريخ تولدها.

3. نفايات منخفضة ومتوسطة المستوى وقصيرة العمر النصفي:

النفايات التي لا تضمحل حتى مستويات الحدود المسموحة في غضون ثلاث (3) سنوات، والمحتوية على نظائر مشعة باعثة لجسيمات بيتا وإشعاعات غاما بأعمار نصفية تقل عن ثلاثين (30) سنة، أو باعثة لجسيمات ألفا بنشاط إشعاعي اقل من أربعمئة (400) بيكرل/جرام، ولا يزيد النشاط الإشعاعي الإجمالي لها على أربعة آلاف (4000) بيكرل لكل طرد من هذه النفايات.

4. نفايات منخفضة ومتوسطة المستوى طويلة العمر النصفي:

النفايات المشعة المحتوية على نظائر مشعة بتركيزات تزيد على تلك التركيزات الخاصة بالنفايات منخفضة ومتوسطة المستوى قصيرة العمر النصفي، لكن تلك التي لا تولد حرارة بمعدل يزيد على ثلاثة (3) كيلووات/متر مكعب من النفايات.

5. نفايات عالية المستوى:

النفايات المشعة المحتوية على نظائر مشعة بتركيزات تزيد على التركيزات الخاصة بالنفايات منخفضة ومتوسطة المستوى الإشعاعي، قصيرة العمر النصفي التي تولد حرارة بمعدل يزيد على ثلاثة (3) كيلووات/ متر مكعب من النفايات.

Appendix 2. List of Publications on Kuwait Solid Waste since 1990.

Authors	Title	Brief Description
Solid waste survey and monitoring		
Koushki, P.A. and A.L. Al-Khaleefi. 1998.	An Analysis of Household Solid Waste in Kuwait: Magnitude, Type, and Forecasting Models.	A random sample of 2,000 households were interviewed, and the 11 private-sector companies responsible for the collection, transport, and disposal of household solid waste were coordinated, along with the Kuwait Municipality More than 200 randomly selected solid waste trucks were subjected to a detailed manual waste classification procedure. Measurements of the actual quantity (by type) of daily solid waste from the truck monitoring survey were used to assess households' reported response accuracy.
Koushki, P. A., and J. M. Al-Humoud. 2002.	Evaluation of Reported and Measured Compositions of Household Solid Waste in Kuwait.	This research addresses the effect of changing population composition on the quantity and the mix of the daily generated solid waste by households. The paper also examines the compatibility between household-reported and landfill site-measured percent compositions of the daily solid waste.
Koushki et al. 2004.	Municipal Solid Waste in Kuwait: Trends and Attitudes on Collection, Separation and Willingness to Pay	This study is based on a survey of 1500 random households, aiming at developing profiles of solid waste generation, the relation of rate to socio-economic, and attitude towards waste separation and willingness to pay for waste management.

Alhumoud, J. M., and A. A. Al-Mumin. 2006.	A comprehensive evaluation of solid waste management in Kuwait.	Recent literature on solid waste management in Kuwait has been reviewed and data analysed on the total amount of solid waste generated in Kuwait. In addition, industrial solid waste, construction and demolition waste, and pharmaceutical waste are investigated and discussed. Moreover, the cost of collection and transportation of household waste in Kuwait is also calculated. Factors affecting the important management issues in the operation of Kuwait's solid waste management system are investigated and discussed.
Alhumoud, J.M. and H. M. Alhumoud. 2007.	An analysis of trends related to hospital solid wastes management in Kuwait.	This paper is addressing the amount of different kinds of solid wastes produced, segregated, collected, stored, transported and disposed off in the governmental hospitals of Kuwait.
Al-Salem, S. M.S., and M. Al-Samhan. 2007	Plastic Solid Waste Assessment in the State of Kuwait and Proposed Methods of Recycling	A proper assessment of Solid Plastic Waste (SPW) in Kuwait will provide a greater understanding to the industry of plastic manufacturing and manufacturers as well as direct the strategic future plans proposed into execution. This research show the results obtained after a years survey and study of plastic solid waste in the state of Kuwait and the surrounding region in order to create a database that can be used in future plans and research projects.
Alhumoud, J. M., M. Altawash, L. Aljallal. 2007.	Survey and evaluation of household solid waste	The objective of this study was to carry out a field survey of the solid waste generation profile in Kuwait. In addition, the paper

	generation and compositions in Kuwait.	examines the compatibility between household-estimated and landfill site-measured percent compositions of the daily solid waste. Hand sorting was used for classifying the collected wastes into the following categories: plastics, paper, metals, cans, leather wood, textiles, rubbers, putrescible wastes, inert materials and miscellaneous.
Al-Salem, S.M. 2009.	Country Report: Establishing an integrated databank for plastic manufacturers and converters in Kuwait.	The aim was to assess the amount of plastic waste being generated from a number of sources. Types, quantities, and recycling information were gathered and fed into the databank. It was noted that most converters of plastic use in-house recycling schemes. These grades possess an import value in excess of 20 million US dollars per year.
Al-Jarallah R, Aleisa E (2013)	Investigating causes contributing to increased municipal solid waste in Kuwait: a national survey.	A survey of 806 households assessing various factors related to solid waste generation, and willingness to contribute to waste collection and treatment.
Al-Jarallah R, Aleisa E (2014)	A baseline study characterizing the municipal solid waste in the state of Kuwait.	Baseline data were collected for the Determination of the Composition of Unprocessed Municipal Solid Waste (ASTM). The results indicated that the average daily municipal waste generation level is 1.01 kg/person. Detailed waste stream surveys were conducted for more than 600 samples of municipal solid waste (MSW). The waste categories included paper, corrugated fibers, PET bottles, film,

		organic matter, wood, metal, glass, and others.
Al-Qallaf et al. 2016.	Analysis and improvement possibilities of waste management at Kuwait Oil Company (KOC)	This paper addresses the waste management system at KOC, both non-hazardous and hazardous. The paper provides data on the amounts of waste generated and the actions that the company is taking currently, and recommendations for improved waste management. The paper provides data on the amounts generated and their categories.
Al-Salem, S. M., A. Al-Nasser, and A. T. Al-Dhafeeri. 2018.	Multi-variable regression analysis for the solid waste generation in the State of Kuwait.	This research used regression analysis to predict solid waste generation rates from a number of sectors within the country, namely the domestic, commercial, building and construction (B&C), and agricultural ones.
Modelling		
AlRukaibi, D. and A. Alsulaili. 2017.	GIS-Based Modeling for Appropriate Selection of Landfill Sites	A macro-evaluation of a GIS criteria analysis model to select the appropriate landfill sites based on quality and quantity analysis. The quality and quantity analyses provided three significant sites (south of Kuwait and one site north of Kuwait).
Alshammari et al. 2008a and 2008b.	A Typical Case Study: Solid Waste Management in Petroleum Refineries	A model was developed that provides the most cost effective petroleum waste disposal details based on the choice of treatment processes, their capacities and appropriate routing of waste streams from a local oil refinery in Kuwait.The model output can be used to assist in making appropriate decisions regarding the petroleum industries

		solid waste management (minimization, processing, landfill etc.).
Management and Recycling		
IBK, 2010	Assessment of Solid Waste Sector in the State of Kuwait. The Industrial Bank of Kuwait, January 2010.	A comprehensive study conducted by the World Bankfor the Industrial Bank of Kuwait, and funded by KFAS. The study covered the quantities of solid waste, the management practices in 2008, the potential for recycling, and a set of recommendations concerning the approach that should be taken by the concerned parties.
Al-Bahar, S., S. Al-otaibi, S. Al-Fadala, A. Abdul-Majeed, M. F. Taha, F. Al-Fahad, A. Al-Arbeid, and T. K. Mukherjee, 2016.	Process Using Multiple Waste Streams to Manufacturing Synthetic Lightweight Aggregates	US9,340,456, MAY 2016)
Al-Meshan. A.M.; F. Mahrous, 2001.	Recycling of municipal solid waste in the State of Kuwait	This study aims at explaining the composition of generation rates of HHSW and commercial solid waste in Kuwait and information about the experience of Kuwait in the field of recycling of paper, glass, plastics, metals and scraps, used oil, and batteries, etc.
Kartam, N., N. Al-Mutairi, I. Al-Ghusain, and J. Al-Humoud. 2002.	Recycling of construction and demolition waste in Kuwait.	The current construction and demolition waste disposal system and recycling options to manage and control wastes in an economically efficient and environmentally safe manner are discussed.
Koushki, P.A., U. Al-Duaij, W. Al-Ghimlas. 2004.	Collection and transportation cost of	The specific aim of this funded research project was to examine and evaluate the efficiency and the effectiveness of the

	household solid waste in Kuwait.	municipal solid waste collection and transportation system in Kuwait.
Kartam, N. et al., 2004.	Environmental management of construction and demolition waste in Kuwait.	This paper presents the current status of C&D waste disposal system in Kuwait and identifies the potential problems to the environment, people and economy. Then, it investigates alternative solutions to manage and control this major type of waste in an economically efficient and environmentally safe manner. The paper describes the feasibility of establishing a C&D waste recycling facility in Kuwait. It concludes by highlighting the major benefits and bottleneck problems with such a recycling facility.
Alhumoud, J. M.,I. Al-Ghusain, and H. Al-Hasawi. 2004.	Management of recycling in the Gulf Co-operation Council states.	The paper discusses the recycling in the GCC.
Bogahawatta, L., H. Karam, and A. M. Abduljaleel. 2004.	Utilization of waste lime kiln dust as an admixture in concrete	
Alhumoud, J. M. 2005.	Municipal solid waste recycling in the Gulf Co-operation Council states.	An overview of solid waste recycling in GCC and proposes strategies for developing the most effective recycling marketing programme considerations and regional co-ordination options
Al-Otaibi, S., and M. El-Hawary. 2005.	Potential For Recycling Demolished Concrete And Building Rubble In Kuwait.	An assessment of the suitability of crushed concrete and masonry for use in concrete and in sand lime brick manufacture. Recycled concrete can be crushed and utilized as aggregates in the production of new concrete. The results also show that fine

		powder can react with silica to produce lime-silca bricks. The production process including autoclaving time and temperature is included along with the properties of the resulting bricks.
Aljassar, A.H., K. B. Al-Fadala, and M. A. Ali. 2005.	Recycling building demolition waste in hot-mix asphalt concrete: A case study in Kuwait.	This paper presents the results of a technical feasibility study into meeting this need by recycling the aggregates obtained from building demolition waste for asphalt concrete. The results showed that the asphalt concrete produced using an aggregate of demolition waste met all the requirements of local specifications.
Al-Salem, S.M., and P. Lettieri. 2009.	Life cycle assessment (LCA) of municipal solid waste management in the state of Kuwait.	In this study, three different municipal solid waste (MSW) management scenarios were developed and compared for the state of Kuwait.
Al-Salem, S.M., 2009	Establishing an integrated databank for plastic manufacturers and converters in Kuwait	Determining the quantities and waste flow of Kuwait. Establishing a databank of converters
Al-Salem, S.M., Lettieri, P., Baeyens, J., (2009)	Recycling and recovery routes of plastic solid waste (PSW): A review	Review of major PSW valorisation technologies *Highest cited publication in chemical engineering by Elsevier (over 1200 citations as of 2019)
Al-Salem, S.M., Lettieri, P., Baeyens, J., (2009)	Kinetics and product distribution of end of life tires (ELTs) pyrolysis: A novel approach in *polyisoprene* and *SBR*thermal cracking	ELT pyrolysis and product extraction. Development of a novel isothermal pyrolysis estimation methods.

Al-Salem, S.M., Lettieri, P., (2010).	Kinetic study of high density polyethylene (HDPE) pyrolysis	HDPE pyrolysis in micro-scale. The development of isothermal kinetics model applicable for PO plastics.
Al-Salem, S.M., Lettieri, P., Baeyens, J., (2010)	The valorization of plastic solid waste (PSW) by primary to quaternary routes: From re-use to energy and chemicals	Case studies of isothermal pyrolysis for PO waste generated from the municipal waste stream.
Al-Salem, S.M. and Lettieri, P., (2010)	On the Pyrolysis of Polymers as a Petrochemical Feedstock Recovery Route	Extended explanatory notes on the pyrolysis in context of thermo-chemical treatment of PSW
Lettieri, P. and Al-Salem, S.M., (2011)	Thermo-Chemical Treatment of Plastic Solid Waste, Chapter 17 in „Handbook of Waste Management and Recycling	PO pyrolysis in content of other polymeric materials and potential for petrochemical industries integration
Al-Fares, R. A. 2013.	Medical waste fly ash recycling for possible use in geo-environmental application.	This research assessed the use of fly ash by mixing it with gatch for possible geo-mechanical applications.
Al-Salem, S.M., 2014	Life cycle assessment (LCA) of thermo-chemical treatment (TCT) technologies integrated to oil refineries in Kuwait	Utilizing a PSW feedstock in feeding a slow pyrolysis unit and integrating it in Kuwait's oil refineries operation and infrastructure.
Alsulaili et al. 2014.	An Integrated Solid Waste Management System in Kuwait	The study addressed designing seven recycling and recovery plants that separately deal with plastic, tires, paper, metal, glass, and organic and construction and demolition (C&D) waste materials; these plants are in

		addition to a sorting plant for the primary sorting of mixed materials. Findings derived from this study showed that 76% of Kuwait's waste are recyclable. The raw materials produced by the recycling plants will be sold to gain a revenue of $ 134 million USD annually, whereas the non-recyclable materials will be sent to a sanitary landfill.
Hussain, H., M. Sebzali, and N. Hussain. 2015.	Technical and economic feasibility of energy production from municipal solid waste incineration in Kuwait	
Al-Salem, S.M., Abraham, G., Al-Qabandi, O.A., Dashti, A.M. (2015)	Investigating the effect of accelerated weathering on the mechanical and physical properties of high content plastic solid waste (PSW) blends with virgin linear low density polyethylene (LLDPE)	Investigating the integrity of blends of PO waste under local and accelerated conditions
Al-Salem, S.M. and Khan, A.R. (2015)	Degradation kinetic parameters determination of blends containing polyethylene terephthalate (PET) and other polymers with nano materials	The development of iso-kinetics of plastic blends and their modelling approach
Al-Salem et al. 2016	Effect of Die Head Temperature (DHT) at Compounding Stage on the Degradation of Linear	Investigating various compounding and processing conditions on the properties of PSW blends for product development applications

	Low Density Polyethylene (LLDPE)/Plastic Film Waste Blends Post Accelerated Weathering	
Al-Fadala, S. 2017.	Suitability of coarse recycled aggregates from construction waste in producing interlocking concrete paving blocks.	
AlDadala, S., E. Al-ali, A. Al-Arbeed. 2017.	Suitability of coarse recycled aggregates from construction waste in producing interlocking concrete paving blocks.	
Al-Salem, S.M., Antelava, A., Constantinou, A., Manos, G., Dutta, A., (2017).	A Review on Thermal and Catalytic Pyrolysis of Plastic Solid Waste (PSW)	A critical review of state of art technologies for pyrolysis reactors and influential parameters
Al-Dhafeeri, A.T., Al-Salem, S.M., Al-Wadi, M.H., Sultan, H.H., Karam, H.J., (2017)	Variation in Gas Chromatography (GC) Analysis in Setting Up Laboratory Protocols for Waste to Energy Novel Fixed Bed Reactor Setups	Development of protocols applicable for handling a novel reactor designed for the pyrolysis of organic waste
Al-Salem et al., (2017b)	Thermal Degradation Kinetics of Virgin Polypropylene (PP) and PP with Starch Blends Exposed to Natural Weathering	The study of the applicability of thermolysis as a recycling means by determining the kinetics parameters of starch blends with PO plastics after exposure to climatic conditions. The study of plastic waste in agriculture applications and how to valorize it.

Ismael, N., and H. Al-Sanad. 2018.	Properties of desert sands reinforced with ground tire rubber in Kuwait	This research addresses useful uses of ground tire rubber using rubber aggregates produced locally as additive in small quantities to the local surface sands. It was found beneficial for many practical applications such as light weight fill, as a drainage layer, and on the grounds of sporting facilities, and in embankment construction
Aleisa, E. and R. Al-Jarallah. 2018.	A triple bottom line evaluation of solid waste management strategies: a case study for an arid Gulf State, Kuwait	A life cycle assessment (LCA) embracing both economic and social perspectives to develop an integrated solid waste management system for Kuwait. Six municipal solid waste (MSW) scenarios (SR1, SR2, ..., SR6) are evaluated using a triple bottom line (TBL) approach that incorporates environmental, financial, and social bottom lines (social BLs).
Al-Salem et al. 2018d	Non-isothermal Degradation Kinetics of Virgin Linear Low Density Polyethylene (LLDPE) and Biodegradable Polymer Blends	Dynamic thermogravimetric analysis of PE blends with high content thermoplastic starch as a means of waste management by biodegradation and thermolysis
Al-Salem, S.M. (2019)	Influential Parameters on Natural Weathering Under Harsh Climatic Conditions of Mechanically Recycled Plastic Film Specimens	Determining the integrity of PSW products developed under local environmental conditions
S. Al-Ghawas, H. Al-Mansour, A. Naseeb, E. Al-Ali, A. A. Boota,	Composting Poultry Waste	

R. A. Al-Kandari, D. Ghloum, and J. Jacob		
S. Al-Ghawas et al	Formulation and Standardization of Plant Growth Media Using Indigenous Materials	
S. Al-Ghawas, M. U. Beg, S. Al-Muzaini	National Plan for Land Application of Sewage Sludge	
Saleh Al-Muzaini, Samir Al-Ghawas, Mirza Beg	Selection of an Effective Sewage Sludge Composting Technology for Kuwait	
General & public awareness of solid waste problem		
د. علي محمد الدوسري ود. جاسم محمد العوضي. 2010.	تدهور الأراضي في دولة الكويت.	A book that includes a review up till 2010 on the disposal of solid waste in Kuwait, including some statistics.
Alhumoud, J. M, and F. A. Al-Kandari. 2008.	Analysis and overview of industrial solid waste management in Kuwait.	The paper addresses industrial and business solid waste in Kuwait.
Al-Yaqout et al. 2002.	Public opinion and siting solid waste landfills in Kuwait.	A survey concerning site selection of landfill sites. The findings indicated that a significant percentage of the responding sample did not know about the various landfill impacts and less than 50% were aware of the negative impacts of landfills on the public health and the environment. The findings directed attention to the role that the media could play in increasing public awareness.
Al-Salem, S.M., (2017).	1st KISR/Italian Workshop on Waste Management:	Book of Proceedings

	Operational Excellence in Waste Management Research,	
Al-Salem, S.M., (2019).	Plastics to Energy: Fuel, Chemicals & Sustainable Implications,	Book
Al-Salem, S.M., (2018).	2nd KISR/Italian Workshop on Waste Management: Integrated Systems & Infrastructure,	Book of Proceedings
Al-Salem, S.M., Sultan, H.H.(2019).	3rd KISR/Italian Workshop on Waste Management: Resources to Resources	Book of Proceedings
Environmental Information System		
د. مروان الدمشقي. 2009	ندوة تعريفية حول مركز الرقابة البيئية (KEMC) ونظام الرقابة البيئية لدولة الكويت ((eMISK	تحديد نطاق البيانات وطرق التحقق من صحة ودقة البيانات والمعلومات البيئية وتشكيل اللجان العلمية وفرق العمل
Talaat, A. 2009.	Environmental Monitoring Information System of Kuwait.	A presentation on eMISKProject Implementation Plan and Expected Outputs
Schurmann, C. 2009	The Need and Potentials of Socio-Economic Data in Environmental Application	A presentation at KEPA addressing various indicators and their importance
Al-Ahmad, M. 2011	Environmental Monitoring Information System of Kuwait (eMISK) - From the Drawer to the Browser: *Making the Change for a Better Presentation of*	A presentation on the progress of eMISK, and the data that have already been collected

	Environmental Data in Kuwait.	
Talaat, A. 2011	Environmental Monitoring Information System of Kuwait (eMISK) – Crowdsourcing and Data Sharing for the Environment in Kuwait	A presentation on the progress of eMISK, and potential of utilizing the data
Al-Ahmad, M. and M. Al-Dimashki. 2013	Kuwait's Vision on Environmental Data Management.	A presentation on the progress of environmental pollution in Kuwait
Environmental Impact of Solid Waste		
Al-Yaqout, A. F., M. F. Hamoda, and M. Zafar. 2005.	Characteristics of Wastes, Leachate, and Gas at Landfills Operated in Arid Climate.	A total of 14 liquid waste samples were collected from different sources at all five landfill sites and from disposal containersin Kuwait representing a model of arid countries. Al-Sulaybiya landfill ~operating! and Al-Qurain landfill ~closed! sites were selected forperforming detailed investigation for leachate characteristics. The chemical characteristicsof leachate clearly indicate that it is highly toxic and concentrated in nature and pause high threat to aquatic environment. Inaddition, the landfill gas production rates were found to be very high.
Hamoda, M.F. 2017.	Management of discarded organic produce from supermarkets and hypermarkets	This study determined the quantities, characteristics and composting of spoiled vegetables and fruits discarded daily from supermarkets and hypermarkets in an attempt to manage such wastes for resource recovery.

Al-Yaqout, A.F. 2012.	Solid waste characteristics in an operating landfill in a developing country.	A detailed laboratory testing program was carried out to determine the characteristics of the waste material in an operating landfill at Al-Sulaybiyah. The results indicated that the samples were mostly decomposed solid waste.
Al-Salem et al., 2019	On the Kinetics of Degradation Reaction Determined Post Accelerated Weathering of Polyolefin Plastic Waste Blends	Determining the impact of plastic waste on environment and application of pyrolysis as a means of mitigation. *Special Issue: Plastic Pollution*

Appendix 3. Background on Wastewater Sludge Utilization

Waste –Domestic Sewage- is of relatively advanced applications when examining local circumstances:

A. The collection network system is state of the art on international scale

B. Waste water collections is suppurated at source between Domestic and Industrial waste water.

C. Treatment plants for waste water are in accordance with most advanced systems worldwide.

D. Even though the treated waste water is put to beneficial use, the solid fraction – sewage sludge- or as my be named if put to beneficial use as bio-solids is currently not widely utilized or recycled.

The hazards associated with land application of bio-solid waste can be identified in accordance with U.S. EPA as:

1. Pathogenic Risks- Can be easily mitigated by regulations on applications rules with the level of sludge pre-treatments.

2. Heavy metals Risks- as indicated on P. 3 This Paragraph can be re-written – additional information's on the topic are in the bottom of the page. Real risks and not imaginary need to identified according to our actual bio-solid contents of these H. M..

3. Ecological Risks. Salts and sodicity; hazardous compounds –i.e. PCBs and many others need to identify and either eliminated at the source are separated at the treatment plant

4. Pharmaceutical waste Risks. This is new topic on international level and need more examination of local conditions . The Hospitals Hazardous waste should be dealt with separately, according to the working system it should not inter the Domestic Sewage networks. The main risk here if it inters the drinking water supplies which is not the case in Kuwait.

Hazard of Buildup of Heavy Metals on Soil and Water Resources. Heavy metal buildup in cultivated land can lead to reduced crop yield and high metal concentration in plant tissue that can pose direct or indirect health risks to consuming population. The range in metal contents in sewage sludge varies widely among various wastewater treatment plants. Usually, metal contents are higher in sludge derived from plants serving industrial areas. Moreover, the metal content and sludge composition will also depend on the extent of treatment (raw or digested sludge), type of treatment (aerobic or anaerobic), if sludge is composted, the type of bulking materials used (domestic refuse, wood chips or straw, etc.) and the method of composting. Also, the metallic concentrations of the generated raw sewage sludge will vary from hour to hour, day to day, week to week and season to season. Therefore, a sludge that is applied to land must be regularly analyzed for its heavy metal and major plant nutrients content.

In Kuwait, operating sewage treatment plants generate collectively about 200 tons of sludge solids per day. Where some of the sludge used to be anaerobicly digested; not in use since the invasion of 1990, rather the thickened surplus activated sludge currently loaded by tanker to a dumpsite outside the seventh ring road; and currently some of the sludge are dewatered, thickened at Riqqa and Jahra and the new Sulaibiah treatment plants . In a preliminary sampling program conducted in the past few decades on the sludge generated from these plants reveal, that about 25-30 % of the sludge solids were sand. Furthermore, the ratio of volatile solids to total dry solids is about 70%, which indicates that a large fraction of the sludge solids is biodegradable. Among the heavy metals analyzed, Zn and Hg were the only elements found in relative significant quantities and slightly above the USEPA of heavy metals limits for 'high quality' levels category. Nevertheless some of this information is more than a decade old and sampling was conducted for relatively short period of six months in the cool season. Furthermore, there are no clear indications on the analytical procedures or instruments used which questions the quality, consistency and validity of these figures and therefore they should be used in a general view that local sludge by the design of separating industrial waste from domestic sludge supplies has a low concentration of heavy metals. However, there is a need for a well-designed testing program that can statistically assess the

potential risk of heavy metals contamination as proposed in Task II of this study. This will require a longer testing period under diverse conditions reflecting the daily and seasonal variations, while applying the most appropriate analytical procedures. The present sludge management program at the MPW/Sanitary engineering division (SED) treatment plants are based upon cost minimization as opposed to further processing for beneficial reuse, especially with the lack of local experience in the further processing of sludge to make bio-solids products.

Certain heavy metals such as B, Cd, Cu, Mo, Ni and Zn, present potentially serious hazard if they are incorporated into farm land without any limitations . Other heavy metals are less of a concern due to their attenuated chemical activities in the soil or by their infrequent occurrence and exceptionally low concentration in the generated sewage sludge. Therefore, under typical agronomic practice, elements such as Fe, Mn, Al, Cr, As, Se, Sb, Pb and Hg would not result in retarded plant growth or consumers exposure to potentially toxic levels of heavy metals. Whereas, higher inputs of Cu, Ni, and Zn within the applied sludge could be phytotoxic since they have considerably higher relative solubility than Cr, Mo, Pb, Se, and V. Furthermore, the limits of heavy metal phytotoxicity will vary depending on the particular element (some are essential plant nutrients), type of crop, soil properties (% clay, organic matter, pH, oxidation /reduction conditions, amounts and forms of iron, aluminum and phosphorus compounds, etc.), degree of sludge stability, time and management practices.

Protecting the food chain from excessive heavy metals is of great importance. It should be pointed out, however, that with high addition rates of sludge and subsequent buildup of heavy metals in amended soils, planted crops would fail (phytotoxicity) before plant tissue metallic concentration reach levels dangerous to human health. Cd, Se and Mo are however exception to this rules. These elements can reach levels that are dangerous to human and animal health before plants die. Cadmium represents the human dietary poison of principal concern in relation to the utilization of sewage sludge on agricultural land. This is because Cd is highly bioavailable for plant uptake and can accumulate in edible portions of crops to levels that could potentially be deleterious to humans, if consumed for a long period of time and in large quantities, while having no apparent effects on crops themselves. The past examination of Cd levels in Kuwaiti domestic sludge indicated very low concentrations of this element way below the levels of 'high quality' sludge category recommended by USEPA. This is not surprising due to the local practice of separating at source the industrial from residential sewage and thus domestic sludge containing traces of this element. This is in agreement, as have been the international indications on residential sludge. All industrial waste especially those related to

hydrocarbon industries are separate from domestic collected wastewater and their waste locally referred to as industrial waste, are under the controls of 'Shuaiba Area Authorities'. These types of sludge have specific treatments and are forbidden to be used in land application, except in specified dumping sites.

The heavy application of sewage sludge can increase the levels of water-soluble organic compounds that can chelate heavy metals to lower soil depth. Furthermore, high rates will promote reducing conditions, which contribute to the leaching of heavy metals. Practices that can limit the downward movement of heavy metals should be utilized to prevent any contamination to the ground water.