

Managing hauled industrial wastewater in Jordan, a case study

Industrial
wastewater
in Jordan

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Abstract

Purpose – The purpose of this paper is to describe a project intended for the implementation of a formal cradle to grave management program for hauled or trucked industrial wastewater in Jordan.

Design/methodology/approach – Industries that do not have treatment onsite or that treat their industrial wastewater to a level not suitable for disposal into sewers or those that do not have access to sewer system have to haul their industrial wastewater to a treatment or disposal facility. At present most industries haul their industrial wastewater to a solid waste landfill site specially designated to receive industrial wastewater. In the program presented here, a manifest system for these industries have been introduced and implemented in a number of pilot projects.

Findings – A manifest form has been devised and used in a number of pilot demonstrations that enabled the formulation of specific conclusions and recommendations. Before implementing this manifest a program that includes training, awareness, governmental enforcement and commitment, and upgrading of disposal sites and laboratories capabilities has to be implemented.

Originality/value – Management of hauled industrial wastewater is very important in a water poor country like Jordan. The introduction of a manifest system and the identification of the problems associated with its implementation are key issues for sustainable development in Jordan.

Keywords Hauled liquid waste, Industrial wastewater, Manifest, Waste management

Paper type Case study

Introduction

Jordan regulates industrial wastewater disposal (whether pretreated or untreated) into sewer system and prohibits this disposal for many different types of industrial wastewater. Many industries are located in areas where they have no access to sewer system even though their untreated or pretreated industrial wastewater is of a quality suitable for sewer discharge. Others do not have onsite treatment or they have inadequate pretreatment facilities. These types of industries have to haul their industrial wastewater offsite. Currently these industries haul their industrial wastewater to a solid waste landfill site specially designated to receive industrial wastewater. The present paper introduces a manifest system that has been used by a selected number of industries as pilot demonstrations. Problems associated with the implementation of the manifest system along with recommendations withdrawn from these pilot projects are identified. Little work has been conducted on such topic as can be observed from the lack of published research papers in the literature.

Hauled industrial wastewater

Industrial wastewater causes pass through of contaminants to receiving water, interferes with biological treatment, causes sludge contamination, and endangers treatment plant's personnel (USEPA, 1999). It also causes interference in treated wastewater reuse options. This is due to the nature of the industrial wastewater and to



lack of equalization or the more concentrated nature of such waste (USEPA, 1999). The USEPA (1999) has reported an incident where an illegal discharge of hauled industrial wastewater contaminated with a solvent has caused a major disruption in the biological treatment of a wastewater treatment plant (WWTP) in the USA, caused respiratory problems to one of the employees of the treatment plant, and contaminated the wastewater. Different WWTPs at different locations have implemented a number of measures to control the discharge of hauled industrial wastewater. For example, the town of York has designated discharge points for industrial hauled wastewater. The wastewater has to comply with certain limits in order to be allowed to be disposed off in these discharge points and many types of industrial wastewaters are prohibited (York Region, 2012). For example, the pH of the wastewater has to be between 4.5 and 11 and has a suspended solids concentration of less than 60,000 mg/l to be allowed to dispose off their industrial wastewater. The town of York also prohibits the discharge at these discharge points any industrial wastewater from slaughterhouses, municipal wastewater pumping station maintenance activities, and any industrial wastewater that contains combustible, flammable, fuel, PCBs, pesticides, or radioactive materials.

The city of Ontario, Canada requires that waste generators, haulers, and receiving facilities should have a permit before being allowed to haul and receive industrial wastewater (Ministry of Environment, 2009). Others have implemented tracking systems for hauled industrial wastewater (USEPA, 2001; Ministry of Environment, 2009; City of San Diego, 2010). In other locations hauled domestic wastewater has to be sampled before being allowed to discharge and hauled industrial wastewater are prohibited to discharge at domestic WWTPs (Town of Amherst, 2006; USEPA, 1999).

The United States Environmental Protection Agency recommends the following program to minimize the effect of trucked industrial wastewater to publically owned WWTPs. These include designating a specific location for disposal, ensuring limited access, ensuring that the plant is aware of any wastewater being discharged, ensuring that the wastewater is manifested, and that the manifest is completed by both the waste generator and the hauler (USEPA, 2001). The quality of the hauled industrial wastewater should comply with the limits established by categorical pretreatment standards for specific industries. Hauled industrial wastewater from industries that are not regulated by categorical pretreatment standards may have local regulations (USEPA, 1999). Publicly owned treatment plants that accept hauled hazardous industrial waste or wastewater are considered to be hazardous waste treatment, storage, and disposal facilities and are subject to the regulations governing hazardous waste (USEPA, 1987).

The city of San Diego is an example of a city that uses a three-page manifest system for trucked industrial wastewater. In this three-page manifest, the generator, the transporter, and the receiving facility each retain a copy of the manifest. No governmental agency receives a copy, and the generator does not receive a copy of the manifest from the receiving facility to confirm that the shipment has been delivered. The manifest system requires that the generator and hauler must have a permit. Industrial waste is hauled to a pumping station that pumps the industrial wastewater to San Diego public sewer system. Trucked industrial wastewaters that have hazardous characteristics, or substances that cause pass through or interfere with the treatment process, or not in compliance with the applicable categorical standards for such industries, are prohibited from discharging to the sewer system (City of San Diego, 2010).

Jordan industrial waste manifest

Many countries have adopted a paper work tracking or manifest system to document the generation of waste, all the subsequent processes that it may go through, offsite transportation, and disposal. The paper work accompanies the waste shipment and provides a record of waste movement from the waste producer through each intermediate management stage to final treatment and disposal. Often the government regulatory agency must receive a copy of the paper work at crucial stages in the transfer to monitor the transfer. Transportation of waste should be subject to a permit issued by the regulatory authority to contractors with approved vehicles and trained drivers. Each vehicle carrying waste should be identified using appropriate symbols or labels. Each movement of waste should require a transport certificate showing the origin and destination. When the waste reaches the treatment and/or disposal facility, the cycle of the “cradle to grave” concept ends. All these steps have to be recorded and be easily tracked, in order to prevent any illegal dumping of waste, and to hold any party accountable of their acts.

The present project has devised a manifest form (Figure 1) that is mainly adopted from the new uniform Resource Conservation and Recovery Act (RCRA) manifest form used in the USA after 2006 (USEPA, 2011). The use of a manifest similar to a hazardous waste manifest like RCRA manifest is due to the fact that this manifest is suggested for both hazardous waste and industrial wastewater, whether hazardous or non-hazardous.

According to manifest chain of custody, the original colored copies of the manifest form will be distributed as follows (see Figure 2):

- Page 1 (top copy): generator copy to the ministry of environment MOE.
- Page 2: generator copy for recordkeeping.
- Page 3: designated (receiving) facility copy to MOE.
- Page 4: designated (receiving) facility copy for recordkeeping.
- Page 5: designated (receiving) facility copy to transporter.
- Page 6: designated (receiving) facility copy for generator.

The project has also devised and recommended a formalized program for the registration and permitting of industrial wastewater generators, transporters, and disposal facilities. The basic tenet of this system is a “Cradle to Grave” tracking system, meaning that the industrial wastewater generators must it from the moment it is produced onsite to the eventual treatment or final disposal site.

Registration is required both for industries and transporters hauling their industrial wastewater in order to get an environmental identification number (EID). The EID number is a requirement that allows waste generators to haul their wastewater offsite. For transporters, the EID number is prerequisite for obtaining a permit from the Department of Transportation allowing the transporting vehicle to transport industrial wastewater.

Pilot projects

Pilot project A

The pilot project was implemented at a receiving and transfer station for sanitary wastes. A recognized problem with this facility is that because Jordan lacks a formal cradle to grave waste management system and a legal framework for enforcement, industrial wastes are mixed with sanitary wastes. It is suspected that mixed sanitary

Industrial Waste Manifest / وثيقة شحن النفايات الصناعية

1. Generator EID / الرقم البيئي للمنشئ

2. Page 1 of 1
صفحة 1 من 1

3. Emergency Phone / رقم هاتف الطوارئ

4. Manifest Tracking Number
رقم متابعة وثيقة الشحن

5. Generator's Name and Mailing Address
اسم المنشئ وعنوانه البريدي

Generator's Site Address (if different than mailing address)
(إذا اختلف عن العنوان البريدي)

Generator's Phone / رقم هاتف المنشئ

6. Transporter Company Name / اسم الشركة الناقلة

EID Number / الرقم البيئي

Vehicle Registration Number / رقم تسجيل المركبة الناقلة

Transporter Company Phone / رقم هاتف الشركة الناقلة

7. Designated Facility Name and Site address / اسم المنشأة المستقبلة وعنوان الموقع

EID Number / الرقم البيئي

Facility's Phone / رقم هاتف المنشأة المستقبلة

8a. HM

8b. Description (Including Proper Shipping Name, Hazard Class or Division, and U.N. ID Number, packing group if applicable) / وصف النفايات (بما فيها اسم المادة المشحونة، تصنيف الخطورة، ورقم تعريف الأمم المتحدة ومجموعة التغليف إذا توفرت)

9. Containers
الحاويات

10. Total Quantity
الكمية الكلية

11. Unit
WT/Vol.
الوحدة

12. Waste Codes
رمز النفايات

1.

2.

3.

4.

13. Special Handling Instruction and Additional Information / تعليمات خاصة بالتعامل مع النفايات أو أي معلومات أخرى

14. Generator's Certification : I hereby declare that the contents of this consignment are fully and accurately described above, and are classified, packaged, and labeled/placarded and in all respect in proper condition for transport according to applicable Jordanian laws and regulations.
شهادة المنشئ: أصرح بأن محتويات هذه الشحنة قد وصفت بشكل كامل ودقيق اعلانه وبأنها مصنفة ومغلقة وتحمل الملصقات اللازمة وبأنها بحالة مناسبة للنقل بما يتوافق مع القوانين والأنظمة الأردنية ذات الصلة

Generator's Name / اسم المنشئ / مقدم النفايات

Signature / التوقيع

Time and Date (Day/Month/Year) / الوقت والتاريخ (يوم/شهر/سنة)

15. Transporter Acknowledgement of Receipt of Materials / اقرار الناقل باستلام النفايات

Driver's Name / اسم السائق

Driver's License Type / فئة رخصة السائق

Vehicle Route (get a permit if you are driving through cities) / مسار واسطة النقل (يجب الحصول على تصريح في حالة المرور داخل المدن)

Permit Number including time of shipment / رقم التصريح بما فيه وقت المسير

Do you have a route permit ☐ Yes ☐ No
هل لديك تصريح بالمسار نعم لا

Signature / التوقيع

Time and Date (Day/Month/Year) / الوقت والتاريخ (يوم/شهر/سنة)

16. Discrepancy: (Fill only if you have discrepancy or rejection of shipment) / التناقض: (يعبأ فقط في حالة وجود تناقض أو رفض للشحنة)

16a. Discrepancy Indication ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection
سبب التناقض الكمية النوع المتبقيات رفض جزئي رفض كلي

New Manifest Reference Number (if applicable) / رقم متابعة وثيقة الشحن الجديدة (إذا استخدمت)

16b. Alternate Facility Name (or Generator) / اسم المنشأة المستقبلة البديلة (أو المنشئ)

EID Number / الرقم البيئي

Facility's Phone / رقم الهاتف

Signature / التوقيع

Time and Date (Day/Month/Year) / الوقت والتاريخ (يوم/شهر/سنة)

17. Waste Management or treatment Methods / طرق إدارة أو معالجة النفايات المشحونة في المنشأة المستقبلة

1.

2.

3.

4.

18. Designated Facility Owner or Operator: Certification of receipt of waste covered by the Manifest except as noted in item 16a
اقرار صاحب المنشأة المستقبلة أو مشغلها باستلام النفايات المشمولة بوثيقة الشحن باستثناء المنصوص عليها في بند رقم 16 أ

Name / اسم الشركة المستقبلة

Signature / التوقيع

Time and Date (Day/Month/Year) / الوقت والتاريخ (يوم/شهر/سنة)

Figure 1.
The proposed
manifest form

and industrial wastes are often delivered in the same tankers. The station consists of two major parts. The first one is an unloading station of municipal wastewater from Amman and nearby areas. The second part is a municipal pretreatment as well as transfer station facility. The pretreatment plant includes screening and grit removal.

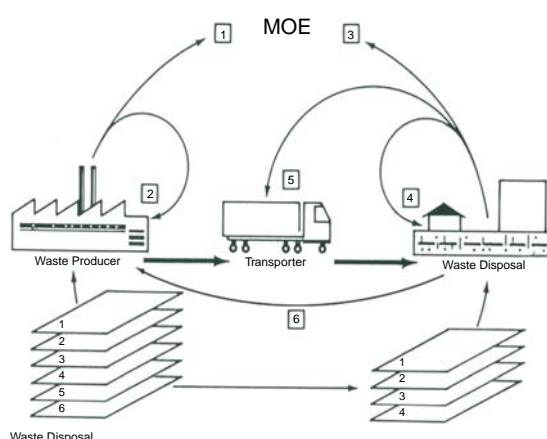


Figure 2.
Manifest distribution
requirements

It receives a total average of $150,000 \text{ m}^3$ per day from three different lines. These lines include a line from Amman public sewer network, the Amman Slaughterhouse, and the unloading station mentioned above.

The tankers pull onto a discharge platform at the unloading station and lower their discharge hoses into the discharge piping. Such piping leads to about ten-cubic-meter concrete underground tank where three pumps are installed to deliver such wastewater to the pretreatment station. The pretreated wastewater is transferred through about 40 km pipeline to Khirbet Al-Samra municipal WWTP, the largest WWTP in Jordan.

The unloading station covers an area of about $4,000 \text{ m}^2$. It receives all types of municipal wastewater including septic tanks' wastewater, municipal sludge from municipal WWTPs in the area, as well as municipal wastewater from different establishments including industry using tankers. Such tankers are labeled basically by an orange color. Added to that, other tankers such as Army Tankers, which are not labeled orange, are received.

A total number of about 176 tankers (vary in size between six and 36 m^3) are basically registered to unload in the station. However, a number of these tankers are not currently active in unloading at the facility. These tankers are registered at the station and licensed by the Traffic Department at the Public Security Directorate. Most of these tankers carry a specific number displayed on the front window. Such tankers are charged about 30 US dollars per month regardless of number or size of shipments. They are permitted to discharge their loads from 6:30 a.m. to 8 p.m. during summer time (May through October) and from 6:30 a.m. to 6 p.m. during winter time (November through April).

The total number of tankers that are registered in Jordan for wastewater transportation is about 340, out of which about 146 are registered in Amman and Zarqa areas, which are the main contributors to the station.

The management of the station does not have any system of differentiating the source of wastewater. Inspectors do not sample any trucks and use only visual and odor inspections to verify quality of wastewater. Even that, visual inspections are not used most of the time. In many cases they receive a mix of industrial wastewater with municipal wastewater. It does not have the capability to confirm whether the tanker contain industrial wastes. It must be noted that such wastewater is discovered only by accident. In case of such violation, the driver is fined and in some cases is turned to the governor for further actions.

It must be noted that the station is located in highly dense residential area and is not designed properly to accommodate the large number of tankers received daily (at least more than 300 tankers per day). In addition, it is understaffed and lacks the qualified people who can manage such facility. It is staffed with only one technician during the two days weekend, and one technician and a supervisor during the five working days. The staff does not supervise the quality of waste received, they only assist in the unloading operation and in rare cases (obvious strange color and odor) they may report violation incident. The facility is not equipped to handle the amount of waste discharged daily and is not lined or paved to prevent accidental spills and overflows. The facility also lacks records keeping procedures, lab facilities, or even basic portable monitoring tools to perform spot checks on receiving waste compositions. This problem places the headworks at the As Samra municipal WWTP in jeopardy from possible overloading of industrial wastes which may contain heavy metals, solvents, and various priority pollutants.

Added to that, the management acknowledges the need for enforcement support from environmental police (Royal Administration for the Protection of Environment). The inefficiency of the pumping station has caused flooding from time to time.

An official exact amount of delivered wastewater to the unloading platform was not available. To estimate the average quantity of delivered wastewater through tankers, data collection of received amounts of wastewater and number of shipments were recorded. Other data that were collected was the time of entrance of shipments into the plant as well as the possible source of wastewater. Such data were useful in identifying any possible industrial wastewater sources as well as periods of wastewater delivery concentration. It showed a wide range of sources including areas outside of Greater Amman Area. It included some types of industrial wastewater such as olive oil mills wastewater on few occasions. Other industrial wastewater sources showed stone cutting and brick plants wastewater as well as textiles dying wastewater on other occasions.

In order to find the sources of wastewater delivered to this station, including industrial wastewater, a formal recordkeeping program was done. In order to build their capacity, the operators were trained on the specific information that should be reviewed on the manifest form. The following steps were undertaken:

- All drivers entering the plant were asked to fill a one page simplified form of the manifest written only in Arabic.
- Every day during the course of this phase of the pilot project, each driver was given a number of manifest forms that are sufficient for about one day shipments. The drivers were told that the form has to be filled by the wastewater generator and signed by both the generator and the driver.
- Members of the Environmental Police (now called the Royal Administration for the Protection of Environment), the Ministry of Environment, and female interns from the University of Jordan were involved in collecting manifests and giving explanations and advice to the drivers.
- The drivers were told that this phase of the pilot project is not intended to be an enforcement tool nor it is intended to fine drivers or generators who are not in compliance with the present environmental regulations. The purpose of the pilot project, they were told, is to get information necessary for the correct implementation of a regulation that will be coming sooner or later.
- Drivers not abiding by filling the manifest were told by the Environmental Police that they will be prevented from entering the plant if they continue to do so.

Problems encountered during the implementation of the pilot project include:

- (1) The small area of the plant in addition to its proximity to the main road caused congestions and delays at the entrance of the plant.
- (2) Industries, individual household generators, and drivers were reluctant and afraid to provide correct information about the source and characteristics of shipped wastewater. Many refused to sign up the document or to provide their names or phone numbers, fearing from any liabilities that they may encounter. Multi story buildings with more than one owner refused to sign the manifest form fearing from legal liability and violation of law. In some cases, female residents refused also to sign the form and provide their names and phone numbers due to their fear from the misuse of the information. In these cases, drivers filled up the manifest form and signed on their behalf.
- (3) Much of the information obtained, during this phase, was based on data provided by the drivers. Therefore information obtained is not totally reliable. However, results were very useful in identifying possible industrial generators sending their wastewater to the plant.

During the study period the amount of wastewater unloaded was about 9,000-15,000 m³/day (mostly from 10,000 to 11,000 m³/day) during weekdays. In Fridays (holiday in Jordan), the amount was about 6,000 m³. The output of this pilot project is that about 50 industries send their wastewater to this station using about 107 tankers out of 139 operating during the pilot project. Most of these industries pretend that their wastewater is domestic wastewater from workers toilets or dormitories. As a result a new pilot project (Pilot Project B) to control industrial generators at an Industrial Estate since it was a major generator of industrial wastewater delivered to this receiving and transfer station has been initiated.

Pilot project B

This pilot project was conducted at an industrial estate which is an industrial complex that has 360 industries that are categorized into ten industrial sectors. These industries range from food industry, pharmaceutical, paper and cardboard, ink, chemical and detergent to metal finishing industries.

The industrial estate has a domestic WWTP that has a capacity of 1,800 m³/day. The plant treats the domestic and pretreated industrial wastewater that complies with the influent standards set by the domestic WWTP. Any industry that does not have a pretreatment units or the effluent of such units do not comply with influent standards has to transport its wastewater offsite. Out of this large number of industries, only 15 industries have been identified to transport their liquid or semi-solid industrial waste offsite.

These industries along with other industries located in the industrial estate were first trained on using the manifest during a training workshop. The management of the estate also participated in the training. In this phase the final form of the manifest was used. Each industry was given a booklet containing 25 forms of four pages manifest. Each booklet has 25 forms each with a manifest tracking number in increasing order of magnitude. The industries were visited individually and in many cases, the company manager has to be contacted personally to take permission to fill up the manifest. Managers were also afraid from any liabilities that they may encounter if they fill the manifest correctly. Industries had again to be assured that the implementation of the manifest will have no consequences or liabilities what so ever.

The conclusions of this phase of the pilot project are summarized below:

- (1) Industries are not capable at the present time to classify whether their wastewater is hazardous or non-hazardous due to the fact that the business of waste and wastewater are usually assigned to people who are not specialists in environmental issues. This job was assigned to employees as an extra task to their main tasks.
- (2) Industries do not, or they pretend that they do not, know where transporters send their wastewater.
- (3) Drivers are reluctant to declare where they send their wastewater.
- (4) There is a shortage in human resources in the Ministry of Environment to follow and enforce the manifest system. Enforcement and commitment from the Ministry of Environment and the Environmental Police (The Royal Administration for the Protection of Environment) have to be strengthened and improved.
- (5) Although the requirements for the manifest tracking system are present in this project, mechanisms to the tracking of the manifest have yet to be established. The entity that should be responsible for the tracking has to be identified. The way manifests have to be sent to the Ministry of Environment should be identified (by mail, Fax, or e-mail). Whether this should be done on a daily, weekly, or monthly basis should also be identified. Distinguishing between industrial waste transporters and domestic wastewater transporters has to be done. A specific color for tankers and a special permit for drivers have to be established.
- (6) The establishment of an electronic manifest would be an appropriate solution to a number of problems that could be encountered with the paper form waste tracking document, as mentioned above. The cost of the manifest paper, the cost and time of mailing or sending the paper format of the manifest, the recordkeeping requirements could all be omitted or reduced by applying the electronic manifest. The tracking of the waste could also be improved as electronic manifests give governmental agencies the opportunity for a real time tracking of tanker trucks.
- (7) Electronic tracking systems via GPS is a very promising way to track tanker trucks.
- (8) There is a vital need for generators training. The training that has been conducted so far was only conducted to generators in specific locations, and did not reach every industry in Jordan. In addition, training so far was conducted to a number of industries with no common similarities, and therefore was general. Training has to be conducted for each industry sector alone, thus training materials can then be tailored to the specific industry involved in training. Auditing could also be conducted to train generators on the various aspects of the manifest system. The government should therefore roll out training to wider industry audience.
- (9) There is a need for an awareness campaign to disseminate the requirements of this system to all industrial waste generators and drivers and to the public as a whole. The public should and has always been a helping hand to regulatory agencies in Jordan.

- (10) There is a need to upgrade the disposal sites by providing them with technically qualified personnel and state of the art lab equipment. There is a need to devise strategies, costs, and identify financial resources for upgrading waste receiving facilities
- (11) Establishing and enforcing the manifest system would therefore require a sustained flow of financial resources. Establishing a fee for registration and fine mechanism for enforcement are essential elements of such financial resources. The Ministry of Environment should enforce a yearly registration requirement with sufficient fees, and the environmental police should be proactive in fining waste generators and transporters for failing to comply with the requirements of the manifest system. This should offset the additional financial requirements needed for an effective enforcement of the manifest system.
- (12) It is clear that there is a financial burden from the implementation of the manifest system to waste generators. This, however, along with new policies and legislation, should become an incentive to support waste minimization and pollution prevention measures, reducing and probably eliminating the overall financial burden. It was found during the implementation of the pilot projects that industries were reluctant in investing on waste minimization or treatment facilities due to the fact that the present “no action” approach is the cheapest alternative.
- (13) In order to improve enforcement and make it cheaper and easier for industries to comply with the manifest system, the environmental labs at the industrial estates, should be upgraded and seek certification in the areas relevant to the manifest system.

Pilot project C

This pilot project was also implemented at another industrial estate that has also a domestic WWTP. Industries that are not allowed to discharge at the treatment plant send their wastewater to the single landfill that accepts industrial wastewater. It is used for the disposal of both municipal solid waste and liquid waste. Liquid waste is discharged in a series of semi-lined and unlined surface impoundments that until very recently accepted both industrial and sanitary wastes in common impoundments. The facility has been partitioned such that industrial wastes (predominantly blue water from textile plants) are now deposited into designated lagoons, with sanitary wastes being sent to a domestic WWTP near the landfill site. Recently, however, a new lined pond, with high-density polyethylene, for olive mill wastewater has been constructed. The solid waste is landfilled in specially constructed cells. The main source of the industrial wastewater is from garments, olive mill, slaughterhouse, and dairy industries. In addition, the site receives dry sludge from the WWTPs in the northern region.

Industries at the industrial estate already are implementing something similar to the manifest system for billing purposes. Although transporter records are produced at the landfill site, these records are neither maintained nor reviewed by the operators. There are no accurate records of how much industrial wastewater has been deposited there. In addition, there is no current tracking of industrial wastes.

This industrial estate contained 98 operating facilities at the time of the pilot project distributed in nine industrial sectors (Engineering (metal and electrical), pharmaceutical, packaging, chemical, leather, food, furniture, plastic and rubber, textile and garment) in addition to services sector. The number of textile and garment

companies is 56 comprising nearly 57 percent of the industries in the industrial estate. From the initial review and assessment, out of 98 operating facilities 11 industries were identified to be generating industrial wastewater (wet industries). Majority of the factories generates only domestic sewage and therefore are known as “Dry” industries, in addition to solid waste such as fabric scraps and used packaging material. The industry sectors (services, wood, leather, and packaging) were identified by the estate as non-industrial wastewater generators.

All domestic wastewater generated at the industrial estate is disposed to the existing estate gravity sewer and is treated onsite at the existing domestic WWTP. Out of the 11 industries mentioned above, four industries in addition to the existing treatment plant were found to fall under the manifest system. The effluent from the domestic WWTP is used for irrigation in the surrounding areas of the industrial estate. Therefore, only sludge from the treatment plant is being disposed off and falls under the manifest system requirements.

Denim washing facilities generates the majority of industrial wastewater in the industrial estate. The garments are usually washed in industrial washers using special processes and chemicals, to produce a desired appearance and texture. Blue water is the wash water generated from the indigo color of denim, and is generated by textile factories in the estate. Denim manufacturing and washing produces large quantities of industrial wastewater, which are still being disposed off in the single landfill that accepts industrial wastewater in Jordan.

The remaining industries either discharge their industrial wastes to the estate sewer network declaring that their waste is complying with the sewer discharge standards. Others have their own WWTPs. The treatment includes pretreatment units and biological treatment. The effluent from these treatment plants is discharged to the estate sewer.

The estate regulates industrial wastewater discharge to its domestic WWTP by imposing pollutant discharge limits (concentration limits) on a number of parameters. These parameters and their concentrations are listed in Table I.

In addition, a number of general requirements are also imposed. All industries must sign an agreement with the management of the estate specifying a number of conditions, in addition to discharge limits shown in Table I, for the discharge of industrial wastewater to the domestic WWTP. These can be summarized as follows:

- The maximum daily discharge to the sewer system = 50 m³/day.
- Industrial wastewater should be separated from domestic wastewater.
- The following are prohibited from being discharged to the sewer system: rain water, softener regeneration water, petroleum products, oily or greasy waste, dyes, materials that may solidify at a temperature between 0 and 40 degrees centigrade, any materials that may pass through the treatment process, any liquid or water containing heavy metals, phenolic compounds, chlorinated organic solvents, sulfides, de-coloring agents, pesticides, corrosive waste, concentrated acids, or concentrated alkalis, any solid or sticky materials, any wastewater with a temperature of more than 45°C.
- Each industry should have a pretreatment unit to comply with the wastewater characteristics allowable to be discharged to the sewer system.

It should be noted that a unified set of parameters for all industries is not the best option to apply. In order to regulate all industries, the number of parameters would be very much high which make it economically unfeasible to conduct laboratory analysis for all parameters.

Parameter	Permissible limit (mg/l) except for pH	
BOD	500	
COD	1,000	
TDS	2,000	
TSS	300	
pH	6.5-9.0	
FOG	50	
MBAS	26	
Na	400	
Al	5	
As	0.1	
Cr	0.3	
Cu	2.0	
Fe	5.0	
Ni	0.2	
Pb	1.0	
Cd	0.07	
Zn	15	
CN	0.3	
Hg	0.001	
P	50	
Cl	500	
B	1.0	

Table I.
Discharge limits
imposed on
industrial discharges
to the estate
domestic WWTP

It is very important to prevent the introduction of toxic pollutants into the estate domestic WWTP as these will either interfere with the operation of the treatment plant, or will pass through the treatment plant and appear in the effluent thus jeopardizing any opportunity to recycle or reclaim the wastewater and sludge. As the effluent from the domestic treatment plant is currently being used for irrigation purposes, extra precautionary measures should be implemented. Toxic chemicals can interfere with the operation of the treatment plant either by inhibiting or disrupting the treatment processes or operations, or its sludge treatment processes use or disposal.

In the pretreatment standards, dilution is usually prohibited as substitute for treatment. The management of the estate should enforce that no industrial user shall ever increase the use of process water, or attempt to dilute a discharge as a partial or complete substitute for adequate treatment to achieve compliance with a pretreatment standard or requirement. The management of the estate may impose mass limitations on industrial users which are suspected of using dilution to meet applicable pretreatment standards or requirements.

The manifest system has been introduced to the management and industries present at the industrial estate through a workshop. All aspects of the manifest system have been introduced to the attendees. After, the industries that fall under the manifest system have been identified; these were visited individually and trained on the use of the manifest. Each industry has been given a number of booklets each having 25 copies of manifests with manifest tracking numbers in increasing order of magnitude.

There was complete implementation of the manifest project at this industrial estate, in general, and the landfill that receives the industrial wastewater due to the following:

- (1) commitment of the industrial estate management and the environmental management team at the industrial estate to the implementation of the manifest;
- (2) commitment from the companies' managements involved in the manifest system implementation;
- (3) the number of vehicles used to transport industrial waste from each of these industries was only one or two for each industry making it easier to enforce the manifest system on the drivers of these vehicles; and
- (4) the close proximity of the landfill to the industrial estate encourages generators and transporters to comply with the manifest system.

A number of recommendations can be withdrawn from the success of the pilot plant at this industrial estate. These can be summarized as follows:

- (1) The Ministry of Environment can delegate its authority in the implementation of the manifest system to the management of the industrial estates.
- (2) After the generator fills and signs the manifest along with the driver of the transporting vehicle, the driver should submit to a designated person at the front gate of the industrial estate, the Ministry of Environment copy of the manifest.
- (3) As most of the industrial estates have domestic WWTPs, domestic wastewater should be prohibited from being hauled outside of the industrial estates.
- (4) In case it is not possible for the domestic WWTPs in the industrial estates to handle all of the domestic wastewater along with treated industrial wastewater, domestic waste hauler should be differentiated from industrial waste haulers.
- (5) The use of a different color code for vehicles transporting industrial waste that distinguishes them from vehicles hauling domestic wastewater could be used.
- (6) The way the manifest should be returned from the designated facility to the waste generator and the Ministry of Environment has to be defined. The following are suggestions in this regard. The return of the manifest copies to the generator and the industrial estate management (as the representative of the Ministry of Environment) should be considered, as the same drivers and vehicles are used by these industries.

Conclusions

A manifest system for industrial wastewater has been devised and used in a number of pilot demonstrations that enabled the formulation of specific conclusions and recommendations. Industries need training to classify their waste. In addition, the mentality of waste generators has to be changed to accept the fact that they are always responsible for their waste, and that their role does not end by hauling their waste offsite. An ongoing awareness campaign for all parties concerned, especially drivers has to be implemented.

The governmental agencies involved have to be committed to the implementation of such system. This includes enforcement, disposal sites upgrade, technically qualified personnel, and state of the art lab equipment. This financial burden should

come from generators of waste which should become an incentive to support waste minimization and pollution prevention measures, reducing and probably eliminating the overall financial burden.

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