

University of Bahrain

College of Engineering

**Department of
Mechanical Engineering**



Safety Evaluation of Transportation of Raw Sewage by Trucks

Thesis submitted in partial fulfillment of the requirements for the degree
of Master of Science in Engineering Management

Prepared by:

Fatima Hameed Qambar Ebrahim

20061078

Supervised by:

Prof. Elamin M.Elkanzi

Co-Supervisor

Prof. Saad Suliman

University of Bahrain
Kingdom of Bahrain

January 2017

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Graduate Studies Council

Thesis Discussion Committee Decision

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The Discussion Committee met on 29/3/2016 (day and date) in Hall no. 14-162 (hall/room no.). Upon discussing the student whose details are stated above in public, the discussion committee recommends the following:

The student awarded grade A In the thesis subject IEN 598 Engineering Management

☐ Without making any changes to the thesis

☒ After making the modifications attached with this decision

Discussion Committee Members Approval:

Name	Signature
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2. <u>Prof. Sand Sultan</u> (Internal Examiner)	
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Abstract

As the Kingdom of Bahrain's population and development expands, sewage transport becomes an ever increasing requirement. Trucking the raw sewage plays a major role in the sewer transportation industry and due to the risk associated with this type of transport, a safety evaluation of the practices of this industry was deemed necessary. Site visits to several sewage trucking companies, related authorities and municipalities were conducted alongside distribution of a questionnaire to all the listed trucking companies in the Kingdom in order to gather the required data to perform the evaluation based on selected factors which were deduced from reviewing (international) literature on the subject. Four main factors were selected to form a comprehensive safety assessment model of raw sewage transportation by trucks namely: safety policy compliance, route planning effectiveness, accident management and vehicles reliability. The analysis was then carried out by using the descriptive and quantitative methods to weigh up the compliance to these factors. The study also included a safety mapping section to visualize the outcome of the evaluation of the factors of the safety assessment model. The safety mapping is a new approach in safety analysis. Also, the development and use of indices in analyzing both objective and perceptual questionnaire questions and they represent the main contributions to safety studies.

The conclusions drawn from the study were that the trucking companies with large fleet size uphold the safety principles more than the smaller companies; the trucking companies focus on the needs of their clients and overlook the safety requirements; and a safety assessment model has been suggested in order to evaluate the level of safety performance by the trucking companies. The main recommendation drawn were the developed model can be used as a base to draw up a comprehensive safety compliance check list for raw sewage trucking to be used by the authorities and the trucking companies.

Dedication

I thank Allah for giving me the strength to be able to complete and dedicate this work to my country. A special dedication to my deceased mother as it was her wish to see me complete the master's degree. I also dedicate this to all my family, to my husband, and to my son. A feeling of gratitude also to my beloved auntie for her support and continuous care.

Acknowledgment

I would like to express my profound gratitude to my thesis supervisor, Professor Elamin M.Elkanzi, for his continuous guidance and assistance. I extend this gratitude to Professor Saad Suliman for his valuable input in the development of this thesis.

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Chapter One

Introduction to the Study

1.1 Introduction

1.2 Research Problem

1.3 Research Questions

1.4 Research Objectives

1.5 Research Significance

1.6 Research Setting

1.7 Definition of Terms

Chapter One

Introduction to the Study

1.1 Introduction

Through history, there have been several sewage management strategies and treatment technologies implemented worldwide. The management strategies can be categorized as either centralized, where all the sewage is collected and conveyed to a central location for treatment and disposal, or de-centralized, where the sewage is treated or disposed of on-site near the source. The reasons for a particular preference were based on a combination of cost, urban development patterns, the nature of sewage e.g. industrial or toxic waste, and other factors. The urban sewage management strategies and treatment technologies from the early nineteenth century up to the present day has under gone several developments. During the middle of the nineteenth century, the centralized water-carriage sewer system replaced the ailing decentralized privy vault-cesspool system. From the end of the nineteenth century to the present day, centralized management has remained the preferred urban sewage management method, though the implemented technology has changed. During the past few decades, however, renewed interest in previously discarded decentralized management alternatives has been spurred by urban development patterns that have changed sewage management strategies (Steven J. Burian, 2000).

The growth of communities and cities over the years, and the negative impacts caused to the health of populations and environment due to discharge of sewage, this has led to the importance of finding ways to safely collect and discharge sewage and then treat it. The focus was

always on developing ways of conveying raw sewage to natural bodies of water. This process slowly evolved with the advances in technology and the significant development was the construction of networks of sewer to collect sewage and route it to collection pits, wells or to sewage treatment plants (Drechsel, Christopher A. Scott, 2010). The first underground sewer constructed in Paris during the early eighteenth century turned out to be extremely popular. Soon after the success of the project was known, numerous other sewer projects were initiated. The beginning of modern urban drainage practices was initiated in European cities during the nineteenth century. The comprehensive sewer system of London, designed by Joseph Bazalgette, was constructed between 1859 and 1865 (Kirby and Laurson, 1932).

Throughout urban populated areas where sewer networks infrastructure have been overlooked due to cost in developing countries, the use of tankers to transport sewage from septic tanks to treatment plants is almost a standard practice which has been in place for a long time.

In the Kingdom of Bahrain, the sewer network infrastructure is not connected to all urban areas. Some areas still rely on septic tanks to collect the local waste from connected cluster of houses and businesses then use trucks to vacuum suck these septic tanks and transport it to treatment plants e.g. Tubli Sewage Treatment Plant (STP) and the newly constructed Muharraq STP in the Hidd area. This type of transport system has constraints which include safety, cost, environmental and health impacts, and efficiency. The safety, health, and environmental concerns associated with sewage transportation by truck are growing in number and complexity. Raw sewage transported by trucks contain toxic substances, if released to the environments through spillage or odor it can threaten human safety, health, environment and property. The sewage

transportation systems in Bahrain will be taken as an example for this study. Tubli STP is the main central treatment plant in Bahrain which is designed based on a pressurized system which is not fully connected to the network by sewer lines, therefore trucks are used to transport the raw sewage to the plant. Bahrain population growth, urbanization and improved standards of living increase the volume of sewage. Therefore, Tubli STP may not be capable to treat all the waste water from Bahrain areas.

1.2 Research Problem

Despite the development in sewage treatment in Bahrain, there still remain some areas that are not connected to sewage transportation network; hence trucks are used for transporting the raw sewage. The daily transport of raw sewage whether to Tubli or Muharraq STP would create potential safety issues all along the delivery route. As the volume of sewage increases due to development and increase of population, more trucks will be used and therefore a greater risk of spillage and traffic accidents would be expected to occur along the transportation route. These incidents can have a negative environmental and public health impacts on the local area of the accident. The evaluation of the safety of transport of raw sewage by trucks remains a societal concern that should be addressed. The outcome of the evaluation hopefully makes the transportation of raw sewage by trucks more safe, healthy & efficient.

1.3 Research Questions

This research will aim to answer the following questions;

What is the current practice of sewage transport by trucks in Bahrain; what are the environmental hazards associated with sewage transport by

trucks; How to improve the safety of the sewage transport by trucks; How to implement safe practices of road transportation of sewage.

1.4 Research Objectives

Consistent with the research questions, the objectives of this research are:

First to review the sewage transportation methods in the Kingdom of Bahrain regarding factors such as volume, techniques...etc. with emphasis on road transportation by trucks.

Second to identify the hazards associated with transporting of raw sewage by trucks.

Third to recommend a quantitative safety assessment model for transportation of raw sewage by trucks.

1.5 Research Significance

This research study could provide information on the issues related to sewage transport in the Kingdom of Bahrain and particularly determine the safety associated with sewage transported by trucks.

Considering that trucking plays a significant rule and covers wide areas in the sewage transportation in the Kingdom of Bahrain, and considering the health and safety risks of this type of sewage transport that can impose on the population and environment; this study aims to conclude and come up with recommendations which would help contain, reduce and better manage the safety of sewage transport by trucks. Hoping these recommendations will help enhance the vaguely existing regulations regarding this matter.

1.6 Research Setting

Review of literature relevant to this research in order to make realistic conclusions that no researches have been published in this particular case in Bahrain.

Data collection in research is the stage where the necessary data useful to the purposes and objectives of the research will be gathered from the field. Different sources of data are to be used for this research work in order to deliver the useful data which are: daily volume of sewage transported by trucks to the treatment plants, and ministerial & international regulations. The data shall be collected by means of a questionnaire which is integrated / complemented by interview.

The analysis of the collected data is to be done using both descriptive and quantitative methods. Both types of methods are used to realize the real sewage transportation by trucks problems and danger of accidents that occur along the delivery route. It will also investigate the safety, procedures, regulations, and accident prevention methods related to the raw sewage transportation by trucks. This will provide methods and suggestions to improve the sewage transportation systems. Quantitative methods, statistical tools and safety assessment are to be used.

1.7 Definition of Terms

1.7.1 Research terminology

- Sewage is a water-carried waste, in solution or suspension that is intended to be removed from a community. (A.C Coen, 2001).
- Hazardous material is any substance or material capable of causing harm to people, property, and the environment. (US DOT, 2004b).
- Safety is ‘the relative protection from exposure to hazards’, ‘no accidents’, ‘the opposite of hazard’ while the hazard is something

that can cause harm, ‘the appropriate handling of a substance or carrying out of an action with the view to efface the possibility of causing an injury or damage’ (Giovanis, 2010).

1.7.1 Abbreviations of the Research

STP	Sewage Treatment Plant
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
pH	Hydrogen Ion Concentration
EPA	Environmental Protection Agency
WHO	World Health Organization
Hazmat	Hazardous Material

1.7.2 Symbols of the Research

CSPI	Compliance of Safety Policy Index
SPF	Safety Policy Factor
OCSPI	Overall Compliance of Safety Policy Index
ISPF	Importance of Safety Policy Factor
SPPI	Safety Policy Perceptual Index
WSSPI	Weight of the Safety Policy Perceptual Indicator
OSPPI	Overall Safety Policy Perceptual Index
ERPI	Effectiveness of Route Planning Index
RPF	Route Planning Factor

OERPI	Overall Effectiveness of Route Planning Index
IRPF	Importance of Route Planning Factor
RPPI	Route Planning Perceptual Index
ORPPI	Overall Route Planning Perceptual Index
AMEI	Accident Management Efficiency Index
AMF	Accident Management Factor
OAMEI	Overall Efficiency Accident Management Index
IAMF	Importance of Accident Management Factor
AMPI	Accident Management Perceptual Index
WAMPI	Weight of the Accident Management Perceptual Indicator
OAMPI	Overall Accident Management Perceptual Index
VRI	Vehicles Reliability Index
VRF	Vehicles Reliability Factor
OVRI	Overall Vehicles Reliability Index
IVRF	Importance of Vehicles Reliability Factor

Chapter Two

Theoretical Framework and Literature Review

Chapter Two

Theoretical Framework and Literature Review

Historical accounts of ancient civilizations (e.g. Indus and Minoan) suggest urban drainage systems were constructed with great care and that the objectives of the systems were to collect rainwater, prevent nuisance flooding, and convey wastes. The systems that eventually met their objectives likely did so after trial-and-error modifications. In general, planning and design were limited. Few numerical standards existed for urban drainage and engineering calculations were not used during design. Despite the lack of optimization and the use of trial-and-error construction methods, numerous ancient urban drainage systems can be rated as successful. Lewis Mumford summarized the state of ancient urban infrastructure when he stated that ancient sewer systems were an uneconomic combination of refined technical devices and primitive social planning (Mumford, 1961). Sewage is liquid waste that is derived from domestic, industrial, commercial and institutional sources (Katyal and Satake, 2001). Within an urban setting, it also includes water run-off from the streets. Although only a small fraction of sewage (0.05%) consists of waste material, the discharge of raw sewage into watercourses can lead to serious levels of pollution (Jackson and Jackson, 1998; Moyo, 1997). That is why it is necessary to treat sewage before it is allowed to flow into natural watercourses such as streams and rivers. Sewage treatment seeks to achieve three objectives, which include: to reduce the pathogen content of waste, to decrease its Biological Oxygen Demand (BOD) and to reduce its solids content (Jackson and Jackson, 1998). Different users consume water and contaminate it with different organic and inorganic compounds. Substances subject to regulatory discharge

controls are considered contaminants and more may be organic or inorganic in nature. Municipal wastewater is mainly generated from domestic sources and usually contains high content of various organic and inorganic compounds, which are easily utilized by different types of microorganisms (Bentzen et al., 1995). Wastewater is a very complex system including a great number of microorganisms divided into specific classes that exist in bulk water phase, biofilms and sewer sediments (Hvited-Jacobsen et al., 1999). Furthermore a great number of different fractions of organic matters acting as substances for these microorganisms are found in wastewater. Classes of sewage include sanitary, commercial, industrial, agricultural and surface runoff. The wastewater from residences and institutions, carrying body wastes (primarily feces, urine and semen), washing water, food preparation wastes, laundry wastes, and other waste products of normal living, are classed as domestic or sanitary sewage. Liquid-carried wastes from stores and service establishments serving the immediate community, termed commercial wastes, are included in the sanitary or domestic sewage category if their characteristics are similar to household flows. The factors which contribute to variations in characteristics of the domestic sewage are daily per capita use of water, quality of water supply and the type, condition and extent of sewerage system, and habits of the people. Municipal sewage, which contains both domestic and industrial wastewater, may differ from place to place depending upon the type of industries and industrial establishment. There are various important characteristics of sewage that are needed to be known in order to determine the best method of treatment or discharge. The observations of temperature of sewage are useful in indicating solubility of oxygen, which affects transfer capacity and rate of biological activity. The hydrogen ion concentration expressed as pH is an important distinctive

character of raw sewage. The pH of the fresh sewage is slightly more than the water supplied to the community. However, decomposition of organic matter may lower the pH, while the presence of industrial wastewater may produce extreme fluctuations. Generally the pH of raw sewage is in the range 5.5 to 8.0. In regards of appearance and color, fresh domestic sewage has a slightly soapy and cloudy appearance depending on its concentration. As time passes the sewage becomes dark in color with a distinctive smell due to microbial activity. Sewage contains only about 0.1 percent solids, classified into dissolved solids, suspended solids and volatile suspended solids. It is necessary to estimate the fraction of solids in sewage as this makes up the load on biological treatment units, sedimentation and grit removal systems during sewage treatment. Though sewage contains only about 0.1 percent solids, the rest being water, still the nuisance caused by the solids cannot be overlooked, as these solids are highly putrescible and therefore need proper disposal. Knowledge of the volatile or organic fraction of solid, which decomposes, becomes necessary, as this constitutes the load on biological treatment units or oxygen resources of a stream when sewage is disposed off by dilution. The estimation of suspended solids, both organic and inorganic, gives a general picture of the load on sedimentation and grit removal system during sewage treatment. Dissolved inorganic fraction is to be considered when sewage is used for land irrigation or any other reuse is planned. Organic compounds present in sewage water serve as food for the metabolism process. Concentration of organic matter in sewage water can be deduced by two methods; calculating the Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Both these tests determine the rate of oxygen uptake by the organic metabolism process by organic matter, therefore giving a related measure of the concentration of organic matter in sewage (A.C coen, 2001).

Toxic materials such as copper, chromium and cyanides can find their way into municipal sewage due to the domestic use of chemicals and detergents. Knowing the concentration of these compounds is important if the sewage is to be treated by biological treatment methods or disposed off in streams or on land. Metal concentrations might reach concentrations that are toxic to microorganisms, soil organisms and/or plants. This toxicity might change with time due to kinetic factors or abiotic factors such as drying or rainfall. Identification of metal toxicity in sewage sludge is a study performed in Göteborg University in 2005 where the toxic metals in sewage sludge were measured and it showed that the concentration varied during the year. Typical concentration of toxic copper in sewage sludge was found to be around 1600mg/kg G.Dave Environmental International, (2003).

The composition of raw sewage is varied and the typical composition and treatment limits in the Kingdom of Bahrain are; pH with a range of (6.0-10.3), suspended solids (125 - 500 mg/l) hydrogen sulphide (0-80 mg/l), COD (220-900 mg/l), BOD (115-450 mg/l), Sulphates (60-91 mg/l), Alkalinity (160-260 mg/l) and total dissolved solids (2,710 - 3,590 mg/l) - (Ministry of Works, Sewage Treatment Agreement, Bahrain 2011)

The hazard classification of raw sewage is somewhat ambiguous. Different agencies and local authorities consider contact with raw sewage hazardous to different extents and have devised different methods in dealing with sewer damage, spill and contamination. Hazardous waste is defined as a waste with properties that make it dangerous or capable of having a harmful effect on human health or the environment. Hazardous waste may come in many forms, including liquids, solids, gases, and sludge. Exposure to raw sewage is a human health hazard that should not be taken lightly, argues Dr. Virginia A. Caine, the infectious diseases specialist of the University of Indianapolis (1999). She adds, the effects

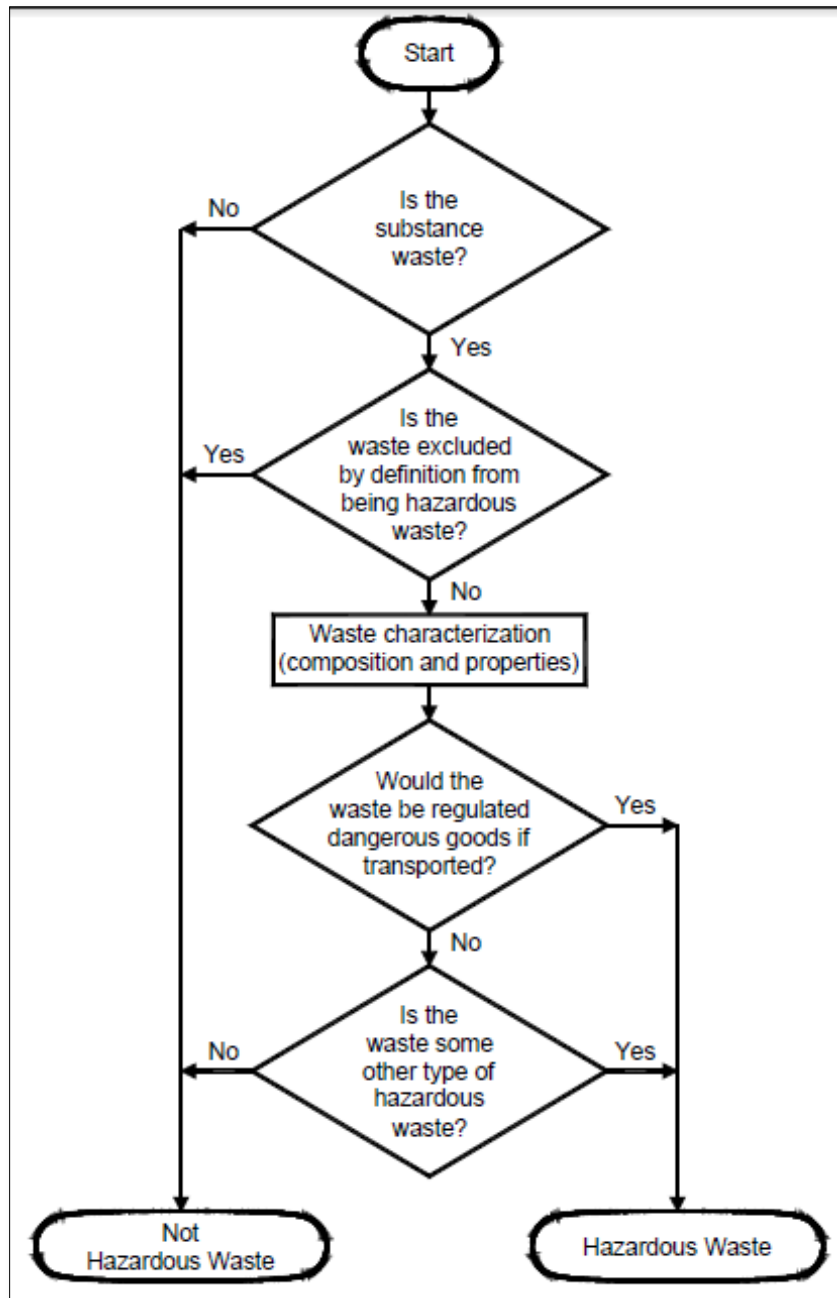
of direct contact with raw sewage and the adverse effects the most vulnerable citizens such as the elderly, young children, pregnant women and those that have compromised immune systems i.e. people with HIV, transplant recipient and cancer patients is studied. More than 50,000 hospitalized cases occur annually in the United States due to sewage contamination of water. The Environmental Protection Agency (EPA) estimates that 7 million people get sick each year from sewage dumping or exposure to raw sewage. World Health Organization (WHO) estimates that 1.5 million preventable deaths per year result from unsafe water, inadequate sanitation or hygiene. These deaths are mostly young children. Another 860,000 children less than five years old are estimated to die annually as a direct or indirect result of the underweight or malnutrition associated with repeated diarrheal or intestinal nematode infections. EPA ranks septic systems as one of the top five sources of groundwater contamination. The study only gives identification of health effect on exposure to raw sewage and contamination but does not aim to classify the hazard into any category.

Hazardous waste may come in many forms, including liquids, solids, gases, and sludge. To cover this wide range, the EPA has developed a system to identify specific substances known to be hazardous and provide objective criteria for including other materials around. There are regulations and guidelines for determining what exactly is waste (called a solid waste) and what is excluded from the hazardous waste regulations, even though it otherwise is a solid and hazardous waste (EPA/RCRA Hazardous waste identification, 1998).

Correct classification is the foundation for ensuring that the collection, transportation, storage and treatment of waste is carried out in a manner that provides protection for the environment and human health and in

compliance with legal requirements. From First June 2015, the EPA waste classification is based on; the EU Commission Decision of 18 December 2014, amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC of the European parliament and of the Council (2014/955/EEC) [referred to hereafter as ‘The List of Waste (LoW)’]. And the EU Commission Regulation No 1357/2014 of 18 December 2014, replacing Annex III to Directive 2008/98/EC of the European Parliament and of the Council on waste and repealing certain Directives.

In essence, hazardous waste is defined by a process of elimination. The composition, properties, and origin of a waste are checked against a series of excluded substances, criteria, and descriptions. A waste is a hazardous waste if no exclusion is applicable and any of the criteria are exceeded or the waste matches any of the descriptions. A standard sequence of steps is followed for this checking process. The steps follow from the definition of hazardous waste and are described in more detail below. Figure (2.1), Evaluation Flowchart, shows the process schematically.



(Hazardous Waste Legislation Guide, June 2005)

Figure (2.1)
Hazardous Waste Evaluation Flowchart

According to the regulations, definitions and the flow chart above, we can deduce that domestic raw sewage is classified as non-hazardous waste by definition and composition while contained i.e. in vessels, septic tanks, sewer systems and trucks. Whereas, in a case of a spill or de-containment,

some of the composition of raw sewage like hydrogen sulphide release to the environment or the direct contact with the sewage can be hazardous to personnel and the environment. Therefore, raw sewage cannot be excluded from being hazardous while transported by trucks.

According to the US Department of Transportation (US DOT), a hazardous material (hazmat) is defined as any substance or material capable of causing harm to people, property, and the environment. Dependence on hazardous materials is a fact of life in industrialized societies. There are thousands of different hazardous materials in use today (US DOT, 2004b). The United Nations sorts hazardous materials into nine classes according to their physical, chemical, and nuclear properties: explosives and pyrotechnics; gasses; flammable and combustible liquids; flammable, combustible, and dangerous-when-wet solids; oxidizers and organic peroxides; poisonous and infectious materials; radioactive materials; corrosive materials (acidic or basic); and miscellaneous dangerous goods, such as hazardous wastes (UN, 2001).

Design and operation of sewer affect sewer process. Inversely, knowledge of in-sewer process can be considered in the design and operation of a sewer network. The types of sewer determine, to a great extent, the aerobic or anaerobic processes needs. Furthermore, ventilation of sewer may affect the buildup and dispersion of odorous and toxic substances produced by microbiological processes (Hvitved-Jacobson, 2002). The flow in sewer maybe controlled by gravity (Gravity Sewer) or pressure (Pressure Sewer) they follow natural falls of the ground. Sewer should however, be laid at such gradients as will produce velocities sufficiently high to prevent the deposition of solids matters in the invert. The minimum gradient to be adopted should normally be such that velocity of the flow does not fall below 0.8m/s at full bore. Maximum gradient to be adopted should be such that the velocity of flow is not

greater than 4.0m/s when flowing half or full bore in order to prevent scouring of sewer by erosive action of suspended matter (MS1228: 1991) in partially filled gravity sewers, transfer of oxygen across air-water interface (reaeration) is possible and aerobic. Hence, transportation plays a significant role for hazmat. The magnitude of this role depends on the size of a country, population growth, urbanization and improved standards of living. There are different methods for transporting raw sewage away from the source which is usually household or urban areas to the treatment or discharge location. These methods come under two main transportation principals, namely; gravity conveyance and pressurized sewer, and one auxiliary system which utilize trucks for transportation. The conventional gravity sewer system is designed with many branches. Typically, the network is subdivided into primary (main sewer lines along main roads), secondary, and tertiary networks (network at the neighborhood and household level).

The most economical design for sewer gradient is obtained when they follow natural falls of the ground. Sewer should however, be laid at such gradients as will produce velocities sufficiently high to prevent the deposition of solid matters in the invert. The minimum gradient to be adopted should normally be such that velocity of flow does not fall below 0.8 m/s at full bore. Maximum gradient to be adopted should be such that the velocity of flow is not greater than 4.0 m/s when flowing half or full bore in order prevent scouring of sewer by erosion action of suspended matter (MS 1228:1991). In partially filled gravity sewers, transfer of oxygen across air-water interface (reaeration) is possible and aerobic heterotopic processes may take place. In Bahrain's gravity sewer system, oxygen concentrations are typically 1 to 4 mg/l (Muharraq STP STA 2013). Therefore, oxygen consumption and exchange processes in water phase, biofilms and at sediment/water and water/sewer atmosphere

surfaces play an important role for changes in wastewater composition (Hvived –Jacobsen, 2002). Biofilms in a gravity sewer is typically 1 to 3 mm thick. The thickness of the organic –rich and cohesive sediment may vary considerably, but several centimeters are common and anaerobic conditions – except for surface- exist (Nielsen et al. 1992). Since wastewater always moving along gravity sewer, some small amount of wastewater and particles of various sizes will be retained and settled when flow is slow. Odor and corrosion are seen in some gravity sewer systems. Conditions that increase the risk of sulphide production from sulphate reduction are: high temperatures, low flow velocities, large water depth with insufficient reaeration, and large biofilms to bulk water rations, high COD concentration, sediment deposits and stagnant wastewater in e.g. septic tanks (Nielsen et al. 1992). Furthermore if such wastewater subjected to high turbulences, stripping of Hydrogen Sulphide (H_2S) and other odorous compounds take place, potentially resulting in corrosion and odor problems.

A fundamental and conceptual description of microbial system in gravity sewers in terms of wastewater organic matters transformation is presented by Hvtived-jacobsen et al. (1998). Pressure sewers are permanently full flowing sewers, which operate internally and do not allow for reaeration. The flow velocities in sewers department on pump capacity and actual flow (Nielsen at al. 1992). Strict aneraobic conditions may exist except for initial part of a pressure sewer. Sulphide production and in attending consumption of biodegradable organics may take place specially in 0.1 – 0.5 mm thick biofilms at sewer (Nielsen at al. 1992). Pressure sewers may be completely full once the pumping stops. Therefore, flow velocity in pressure sewers is often fast enough to prevent accumulation of settled materials. The residence time in the sewers network affects the degree of transformation that may occur the residence time depends on the size of

catchments and specific sewer characteristics, such as slope and length. The residence time is often relatively high in pressure sewers, principally during night time hours (Hvitved – Jacobsen, 2002).

Hazmat transport incidents can occur at the origin or destination (when loading and unloading) or en-route. Incidents involving hazmat cargo can lead to severe consequences characterized by fatalities, injuries, evacuation, property damage, environmental degradation, and traffic disruption. In 2003, there were 488 serious incidents (among a total of 15,178 incidents) resulting in 15 deaths, 17 major and 18 minor injuries, and a total property damage of \$37.75 million (US DOT, 2004c). About 90% of hazmat incidents occur on highways. (J. Yang et al. 2010) stated in their survey that 60.6% of accidents were initiated by driver errors (i.e., traffic accidents) and that most hazmat accidents occurred in general roads were caused by traffic accidents. Moreover, Changing et al. (2012) confirmed that the hazmat accidents statistical data from his homeland in China and abroad showed the hazmat transportation accidents constituted from 30 to 40 per cent of all reported hazmat accidents, and traffic accidents were main causes. Based on latest statistics, many accidents involving hazmat transported by road caused catastrophic losses to humans and environment in China. Therefore, many studies were done by the Chinese public (Zhao et al., 2012) or the government. More attention should be given to the possibility of accidents; their potential severe consequences must be studied due to the dangerous properties of some chemicals transported by road, the high volume of road traffic, and the presence of populous residential areas in the vicinity of the accident site. As hazmat transported by road has been an issue during the last few years, different surveys on hazmat accidents have been carried out to analyze the road accidents, including their causes, consequences, severity

and frequency (Zhao et al., 2012; Yang et al., 2010). They studied 322 hazmat transportation accidents in China from 2000 to 2008 using statistical method and concluded that four groups of factors were responsible for these accidents: driver error, mechanical and equipment failure, management failure and external factors. It is widely recognized that the management of safety plays an important part in achieving and maintaining safety standards. Safety management practices are a vital ingredient of comprehensive safety management systems. Safety management practices can influence and shape employees' attitudes towards the importance of safety and can contribute to their safe behavior. Safety management practices have been found to have positive effects on increasing driver safety perception (Newnam et al. 2008), driver safety behavior (Newnam et al. 2002, DeJoy et al. 2004) and reducing crash rates (Moses and Savage 1994) in general fleets. Specifically, particular safety management practices have been reported to be associated with positive safety outcomes. For example, Mejza et al. (2003) reported the effects of driver hiring practices, driver training, and reinforcement activities and Park et al. (2005) reported positive effects from the control of hours of service. A great deal of research has been done to determine the main contributing factors in heavy vehicle road crashes and associated injury. Examination of data collected for 967 heavy vehicle crashes in the US (Federal Motor Carrier Safety Administration (FMCSA, 2006) found that driver factors included: driver inattention, impairment, decision errors, and speeding. It also found that vehicle factors such as brake problems were important as well as road, traffic and weather conditions. Research on specific risk factors, such as driver fatigue (Feyer et al., 2002), speed (Brooks, 2002), driver pay (Belzer et al., 2002), and vehicle defects (Blower et al., 2010) shows that these are also associated with serious crashes involving heavy vehicles. It

is also expected that different truck weights can present different accident risks due to mass difference, speed difference and the range of other safety factors Jose et al. (2016). Zhao carried out 94 hazmat transportation accidents in China from 2005 to 2009 using Bayesian networks and identified three main direct factors (Human, hazmat packing and loading, and transport vehicles and facilities) and three main indirect factors (road condition, weather, and management) to identify the most important factors that contributed to the accidents and find the relationships among the factors. The results from both studies indicated that human errors followed by management failure are the major factors that can cause accidents. Multiple factors contribute to a hazmat transportation accident, and these factors are often interrelated (Bird and Germain, 1990). Thus it is necessary to consider the interplay of factors when analyzing such accidents. Xie and Wang (2014) indicated that five types of causes are considered in the analysis of heavy vehicle accidents (human factor, vehicle-related defects, tank and safety accessories failures, and road/traffic conditions), HMCRRP (2009) and Zhao et al. (2012), cites that the percentages of accidents attributed to each type of cause is shown in Table (2.1), which shows that 73.8% of causes were attributed to the human related factors including driver errors and attendant error. The next most common set of causes consisted of various types of vehicles related defects (19.6%) and tank and safety accessory failures (11.8%), compromising up to 31.4% of the listed accidents with the value being higher than the average level of hazmat transportation accidents for all types of trucks (approximately 18% Montoya et al. 2009). In addition, previous studies have stated positive relationship between fatigues and crash risk but a minor relationship between the working time and fatigue (Gudars et al., 2015).

Table (2.1)**Main Factors of Hazmat Accidents**

General cause	Percentage of total accidents	Specific cause
Human factors	73.8	Driver: (1) speeding, (2) fatigued driving, (3) mis-operation, (4) inattention, (5) illegal parking, (6) under the influence of drugs or alcohol, (7) other illegal behavior Attendant: (1) neglect his duty, (2) carelessness, (3) illegal operation, (4) poor supervision of cargo
Vehicle – related failure	19.6	(1) Tire, wheel, or tie road failure; (2) brakes failed; (3) steering failure; (4) trailer attachment failed; (5) vehicle self-ignition; (6) other mechanical failures
Tank and safety accessories failure	11.8	(1) Broken tank body, (2) abnormal discharging of the safety valve, (3) tank valve failure, (4) aging and disrepair of tank body and accessories
Road and traffic conditions	5.6	(1) Signs or signal missing, (2) Signs or signal defective or erroneous, (3) poor roadway design, sharper than expected curves, (4) poor roadway design, limited sight distance, (5) inadequate roadway maintenance.

(HMC RP, 2009)

Routing is a critical factor to consider in hazmat logistics, one of the research area related to hazmat transportation is the investigation of the transportation routes .The main objective of hazmat routing is to determine the optimal path(s) for routing the hazmat on a network in order to take into account safety considerations and cost minimization. Many models for hazmat routing have been proposed (P. Leonelli et al, 2000; V. Akg  un, 2003). The selection of the best route for transport was

recently formulated as a “minimum cost flow problem”, which consists of determining, for a specific hazardous substance, the cheapest flow distribution from the origin to the destination nodes (P. Leonelli et al, 2000). The risk from dangerous goods transport by road and strategies for selecting road load/routes are faced in this paper by developing an original site-oriented framework of general applicability. Poor appreciation of factors related to road conditions such as road class, designated speed limits, traffic density, as well as of the population characteristics, is likely to result in compromising safety requirements B.Fabiano (2002) or 2005 faced the risk from transporting dangerous goods by road and the strategies proposed to select road load/routes in his paper, by developing a site-oriented framework of general applicability. A methodological approach for the assessment of standard vehicle and dangerous goods truck flows was applied to a pilot area, allowing a statistical reinforced evaluation of intrinsic enhancing/mitigating parameters. In this way, a safety assessment, sensitive to route specifics and population exposed, is proposed and the overall uncertainties by the risk analysis can be lowered. The developed model, of general applicability, may represent a useful tool not only to estimate transport safety goals but also to define strategies for the reduction of risks. Routing of vehicles carrying hazmat has been the second main concern of the articles about hazmat transportation. From early 1980s to 2014, the researchers have studied on routing the hazardous materials and they mainly focused on local-global routing, transportation mode, vehicle type, single-multi commodity, single-multi objective routing of hazmat transportation. Traditionally, main consideration for hazmat transportation was about cost and safety (Huwang B, 2006). Therefore for routing hazmat while carriers are trying to decrease their transport cost, local or global authorities should care about the safety of population. For

the recent studies on routing hazmat; ,(Samanlioglu F, 2013) proposed a multi-objective mathematical model for the industrial hazardous location-routing problem, (Desai and Lim, 2013) focused on a stochastic dynamic programming approach for hazardous material route selection problem and (Mahmoud Abadi and Seyed Hosseini, 2014) dealt with the hazmat routing problem and fundamental concerns of chaos theory for defining dynamic variables are combined to develop a mathematical model while risk and time are prioritized by corresponding coefficients. The carriers and governments must have some strategies in order to reduce transport risk. Time of the transportation is important. Government and local authorities serve as supervisor to hazmat carriers and, they allocate road segments or available population zones within a time period (Shen X, Xie C, Liu H and Qui Z, 2013).

The carriers should route and schedule their hazmat vehicles according to restrictions of the authorities to minimize transport risk. Different characteristics are considered in the context of network design for hazmat transportation. The road transportation infrastructure is built mainly to connect heavily populated areas and not to avoid them. Therefore, in the context of hazmat transportation, the challenge becomes how to optimize road segments in an existing network to use for safer hazmat transportation rather than identifying the most appropriate ways to expand the infrastructure (Erkut et al. 2007). Designing hazmat transportation is first introduced by (Kara and Verter 2004). They proposed a bi-level integer programming model for network design. They considered the problem with two sides: government and carriers.

According to E.M, G.M and B.M Choueiri (2013), in their overview of the transport sector and road safety in the MENA region, the factors that could directly affect vehicle safety are inappropriate vehicle safety; lack

of vehicle safety standard tests; the vehicle fleet is quite old; incompatibility of vehicles on the roads; and lack of standard safety equipment in vehicles. Steps to ensure vehicle maintenance should be planned and organized like any other business activity states the European Agency for Safety and Health (EU-OSHA). There should be clear procedures and arrangements for daily routines to ensure self and other's safety.

Summary:

Table (2.2) shows a summary of the main topics reviewed in this study. The summary shows that no studies relating to safety evaluation of raw sewage transportation by trucks were carried out in the Kingdom of Bahrain or the neighboring Gulf Countries.

Table (2.2)
Summary of Pervious Studies

No.	Name of the Article	Author(s) / Year	Comments
1	Code of Practice for Design and Installation of Sewerage Systems	Standards and Industrial Research Institute of Malaysia, 1991	Sewer design standards.
2	Transformation of wastewater in sewer systems- A review	Nielsen at al. (1992)	Wastewater properties with sewer systems.
3	The sewer as a bioreactor – a dry weather approach.	Hvitved-Jacobsen, T., Vollertsen, and J., Matos, J.S.(2002)	Deep gravity and pressure sewer systems.
4	Analysis of factors that influence hazardous material transportation accidents based on Bayesian networks: A case study in China	Laijun Zhao a, Xulei Wanga,b, and Ying Qian (2012)	Three most influential factors in Hazmat transportation accidents were human factors, the transport vehicle and facilities, and packing and loading of the Hazmat. These findings provide an empirically supported theoretical basis for Hazmat transportation corporations to take corrective and preventative measures to reduce the risk of accidents.
5	Analysis on Tank Truck Accidents Involved in Road Hazardous Materials Transportation in China	Xiaoyan Shen, Ying Yan , Xaonan Li, Chenjiang Xie and Lihua Wang (2014)	Five types of causes are considered in the analysis of heavy vehicle accidents (human factor, vehicle-related defects, tank and safety accessories failures, and road/traffic

			conditions)
6	Hazardous materials transportation: a risk-analysis-based routing methodology	P. Leonelli, S. Bonvicini, and G. Spadoni (2000)	A new methodology based on risk analysis was used for the selection of the best route for the transport of a hazardous substance. The optimization problem is formulated as a 'minimum cost flow problem', which consists of determining for a specific hazardous substance the cheapest flow distribution, honoring the arc capacities, from the origin nodes to the destination nodes.
7	Dangerous good transportation by road: from risk analysis to emergency planning	B. Fabiano, F. Curro`, A.P. Reverberi, and R. Pastorino (2005)	The risk from dangerous good transport was faced by presenting a site-oriented framework for risk assessment and developing a theoretical approach for emergency planning and optimisation.
8	GIS-Based Route Planning for Hazardous Material Transportation	Huwang B (2006)	Local-global routing and objective routing of hazmat transportation. Cost and safety as main consideration for hazmat transportation
9	A multi-objective mathematical model for the industrial hazardous waste location-routing problem	Samanlioglu F (2013)	Proposed a mathematical model for routing of hazardous material.
10	Solution time reduction techniques of a stochastic dynamic programming approach for hazardous material route	Desai and Lim (2013)	Dynamic programming approach for hazardous material route selection problem.

	selection problem.		
11	Developing a Chaotic-Simulation Based Model for Ranking High Selected Network Links in Hazardous Material Transportation	Mahmoud Abadi and Seyed Hosseini (2014)	Fundamental concerns of chaos theory for defining dynamic variables for hazmat transportation
12	An overview of the transport sector and road safety in the MENA region	E.M, G.M and B.M Choueiri (2013)	Indicate the factors that could directly affect vehicle safety.
13	Model and Algorithm for routing and scheduling in hazardous materials transportation network.	Shen XY. Xie CJ. Liu HX. Qui ZW (2013)	Government and local authorities serve as supervisor to hazmat carriers. Carriers to schedule their hazmat vehicles according to restrictions of the authorities to minimize transport risk.
14	Evaluation of social legislation infringements for international haulage truck drivers involved in road transport accidents.	Gudars et al. (2015)	Positive relationship between fatigues and crash risk but a minor relationship between the working time and fatigue.
15	Exploring the relationship between truck load capacity and traffic accidents in the European Union.	Jose et al. (2016)	Different truck weights can present different accident risks.

Chapter Three

Methodology and Results

3.1 Introduction

3.2 Data Collection

3.3 Safety Assessment Model of Raw Sewage Transportation by Trucks

3.4 Company Safety Policy Factor

3.5 Route Planning Effectiveness Factor

3.6 Accidents Management Factor

3.7 Vehicles Reliability Factor

3.8 Operational and Maintenance Costs

Chapter Three

Methodology and Results

3.1 Introduction

This chapter discusses the methodology and presents the results of the data collected. Section 3.2 briefly describes the approach used in collecting the data, while Section 3.3 presents the safety assessment model and its dimensions. Subsequently, the factors which feed into this model are listed and described in Sections 3.4 to 3.7.

3.2 Data Collection

In order to obtain data to enhance analysis and assessment of the risk faced with transportation of raw sewage by trucking companies; two questionnaires were designed and prepared. The first questionnaire was distributed to the established sewage trucking companies in the Kingdom which was conducted through the interview. Any specific criteria for sampling the companies to conduct the questionnaire, had to be eliminated, due to the minor number of sewage trucking companies in the Kingdom, i.e. all the sewage trucking companies are approached. The questionnaire was distributed to 50 companies and replies were received from 38 companies (i.e. response rate of 76%). The list of trucking companies and the Sample replies are shown in Appendix (1).

The questionnaire is divided into six sections, as shown in Appendix (1). The aim of the first section (Company Safety Policy) is to establish how effective the companies are in devising and implementing safety procedures

to reduce the risks. The second section (Journey/Route Planning) is concerned with the measures taken by companies in planning for trucking journeys and choosing the safest route while trying to reduce the number of journeys made per a trucking job. Section three (Accidents) is constructed to collect data regarding the number of accidents each company faced. The fourth section titled (Vehicles) will look into the integrity of vehicles used by the trucking companies in carrying out the sewage trucking jobs and if the fleet is well maintained and periodically checked. Each of the first three sections consists of two parts: objective and perceptual questions. In addition to these four sections added two sections addressing Operational Costs and Maintenance.

The aim of the second questionnaire is to establish relative weights for all the attributes regarding the main factors which cover the integrity of a proper and safe sewage trucking system. It aims to seek the opinion of the management of sewage trucking businesses and associations about the importance of each factor that affect safety performance.

3.3 Safety Assessment Model of Raw Sewage Transportation by Trucks

Four main factors were selected to form a comprehensive safety assessment model of raw sewage transportation by trucks. The main factors are as follows:

- 1- Safety Policy Compliance
- 2- Route Planning Effectiveness
- 3- Accidents Management

4- Vehicles Reliability

Each main factor will be divided into a number of sub-factors (i) as follows:

1- Safety Policy Compliance

- 1- Availability of predefined transport safety program
- 2- Holding periodic safety meetings
- 3- Established safety committee
- 4- Conducting risk assessment analysis prior to new trucking orders
- 5- Conducting periodic health and safety training for drivers
- 6- Carrying periodical health check for drivers

2- Route Planning Effectiveness

- 1- Availability of route/journey management plan
- 2- Use of accident statistics in route planning
- 3- Completing the target number of journeys per day
- 4- Subjecting all journeys to managerial approval
- 5- Imposing efforts to reduce the number of journeys per job
- 6- Clearly defined and mapped routes
- 7- Identifying potential hazards in the route

3- Accidents Management

- 1- Availability of Accident records
- 2- Availability of accident recovery procedures
- 3- Availability of accident investigation procedures
- 4- Availability of accident spillage incident records

4- Vehicles Reliability

- 1- Vehicle periodical inspections
- 2- Availability of safety policy and procedure in vehicle
- 3- Availability of vehicle spill recovery plan

4- Availability of pre-trip vehicle check list

The identified factors were evaluated through a descriptive and an analytical approach. The descriptive approach presented the logic and implication of each factor and its subsequent sub factors, and the extent of conformity to these factors by the sample companies. The analytical approach was derived through objective and perceptual methods, and indices of conformity were calculated for each method by using the sub factor weights as shown in Figure (3.1).

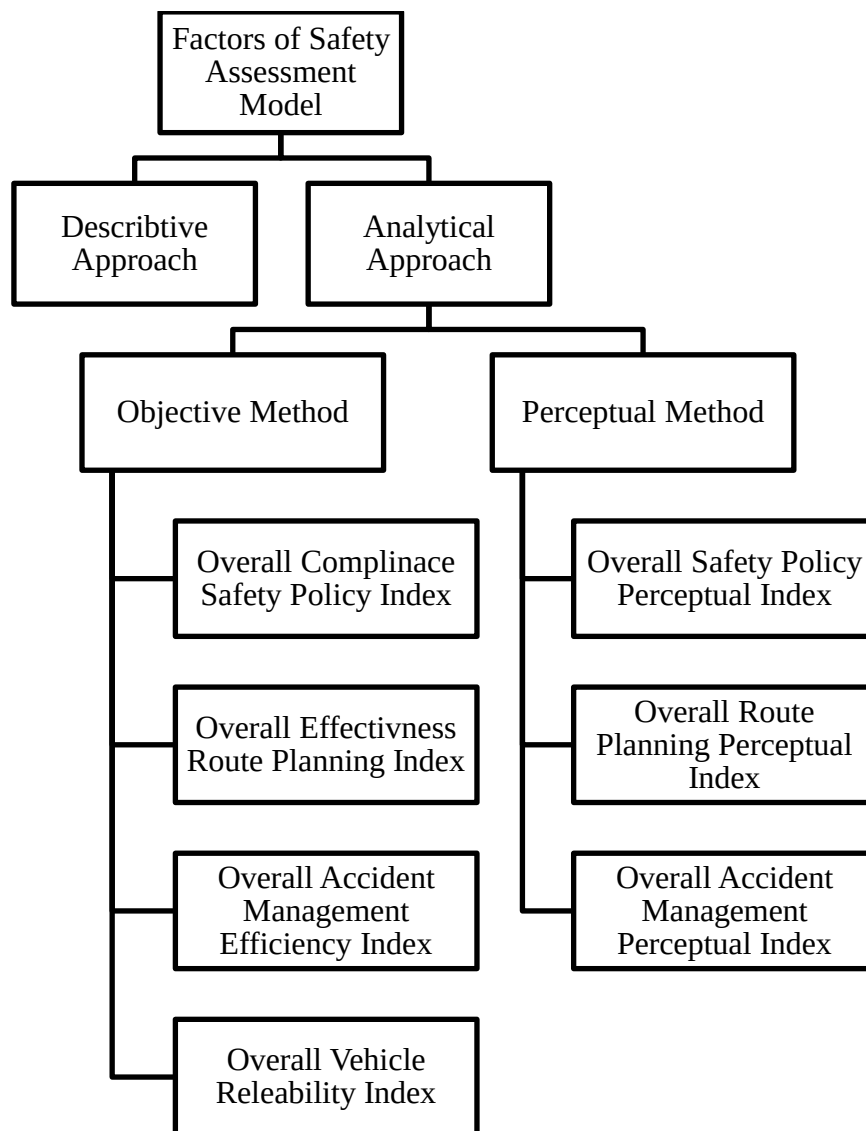


Figure (3.1)

Safety Assessment Model Outline

In order to build a comprehensive assessment of safety management, a questionnaire, see Appendix (2), consists of the above four main factors was prepared and distributed to 10 selected experts to evaluate individually the level of importance of each selected sub-factors. This step is inspired by the idea that expert's ratings will give weights to the different factors. Some of the targeted experts work at a managerial level in Tubli STP and Muharraq STP; others are Principal Environmental Consultants who work in private consultancy firms. All of the experts selected have a minimum of 10 years' experience. So, the questionnaire seeks the opinion of independent parties. The collected responses from the experts and the sewage trucking companies participated in the perceptual part of the questionnaire were translated to relative weights to evaluate the safety policy factor by a compliance index and perceptual indices.

3.4 Company Safety Policy Factor

The first part of Section 2 of the questionnaire is completed by answering a series of Yes or No type questions (objective questions) regarding the availability of a safety program within the company, the conduction of periodical safety meetings, the provision of periodic health and safety training for drivers, carrying periodical health check for drivers, and if risk assessment analysis is carried out prior to performing trucking orders.

The second part of the section is in the form of scaled answer questions (perceptual questions). These questions are aimed to work out how effective the companies are in taking into consideration the truck drivers suggestions regarding route planning and route safety improvement. Also, a question is

asked regarding how proactive the company in applying national health and safety practices. Below are the survey's results for the first part.

3.4.1 Results of objective questions

Question 1: Does the company have a pre-defined transport safety program?

Applying a transport safety program in sewage trucking companies plays a critical role in helping to mitigate accidents and spillages. It is shown in Figure (3.2) that a large number of companies (74%) declared that they have such a pre-defined program within their system of work.

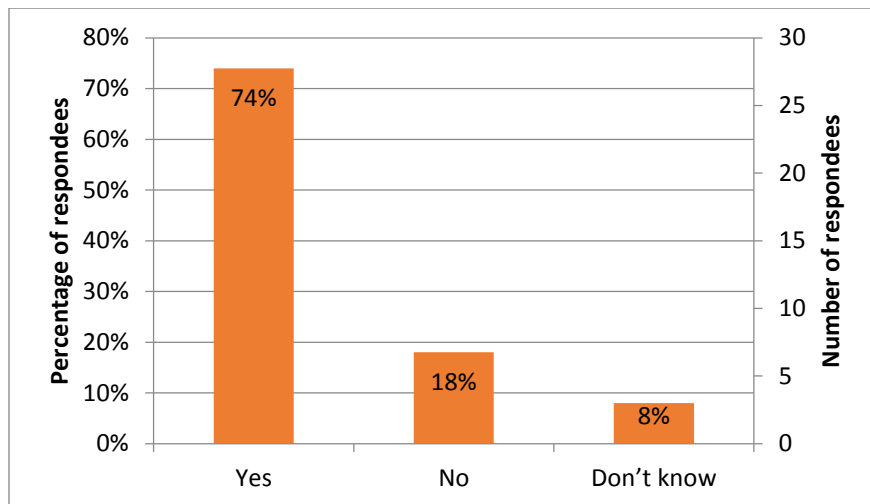


Figure (3.2)

Applying a Transport Safety Program (Question 1)

Question 2: Are periodic safety meetings held?

This second question evaluates if the management of the trucking companies conduct regular meetings to discuss and improve the safety aspect. The majority (55%) of respondents declared good awareness of the matter

although the number of “No” respondents was fairly large as shown in Figure (3.3).

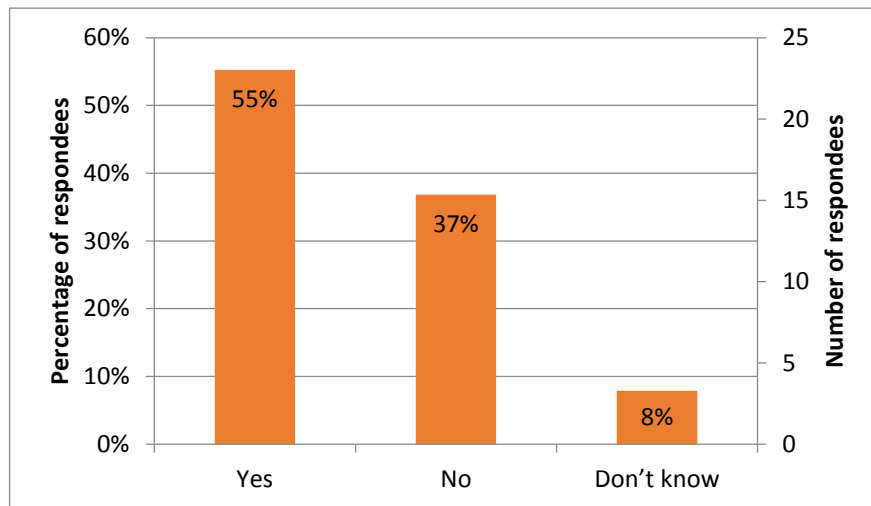


Figure (3.3)

Holding Periodic Safety Meetings (Question 2)

This question also had a second part to it concerned with the frequency of how often such safety meetings are held. The majority of the “Yes” responses declared meetings were held on weekly basis.

Question 3: Is a safety committee established?

This question is devised in order to establish if the trucking company has the tools and the personnel responsible to follow-up and ensure compliance with the safety rules and regulations. As the results show in Figure (3.4), 47% of the respondents replied with “No”. These results shed doubt on the ability and effectiveness of the companies in carrying out or applying the mechanisms of the first two questions above which most companies declared to apply.

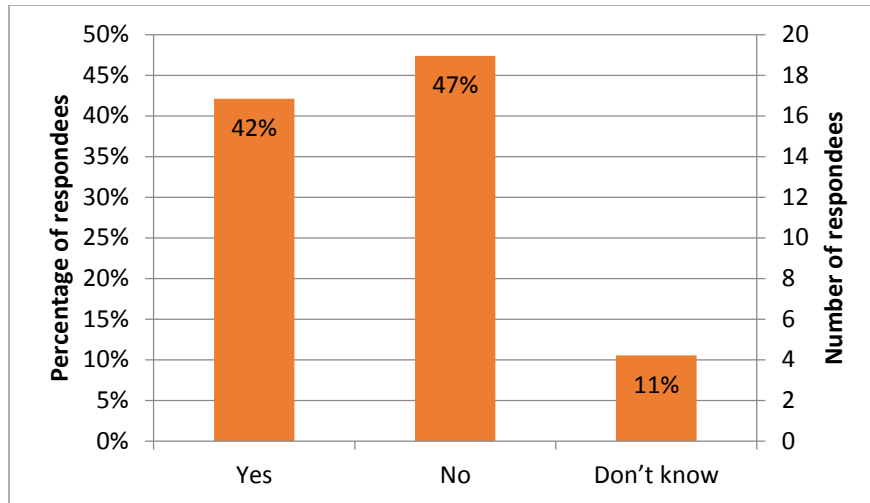


Figure (3.4)

Establishing a Safety Committee (Question 3)

Question 4: Do you conduct risk assessment analysis prior to performing new trucking orders?

This question evaluates if the management of the trucking companies conduct risk assessment analysis prior to attending new trucking orders. The majority (53%) of respondents declared that they do not carry out the risk analysis prior to conducting trucking jobs as shown in Figure (3.5). By carrying out this analysis, the trucking companies will be in a better position to identify the risks that are of a higher priority to their transportation process. Therefore, the trucking company that anticipates and prepares for preventing or reducing these risks can maintain / recover normal service levels in a more cost effective manner than those that do not.

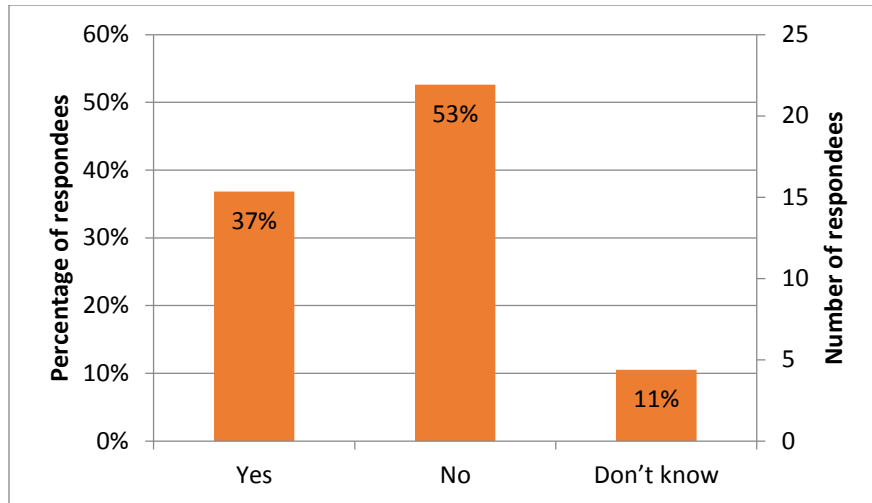


Figure (3.5)

Conducting Risk Assessment Analysis Prior to New Trucking Orders (Question 4)

Question 5: Do all truck drivers get periodical health and safety training?

All personnel transporting hazardous materials must have taken Health and Safety Training. The trucking company management is responsible to provide regular training on health and safety to their drivers as guidance for regulatory compliance; and ensuring that their employees/drivers are complying with elements of the ministerial requirement. Twenty three companies out of the sample stated that employees have received the appropriate training as shown in Figure (3.6).

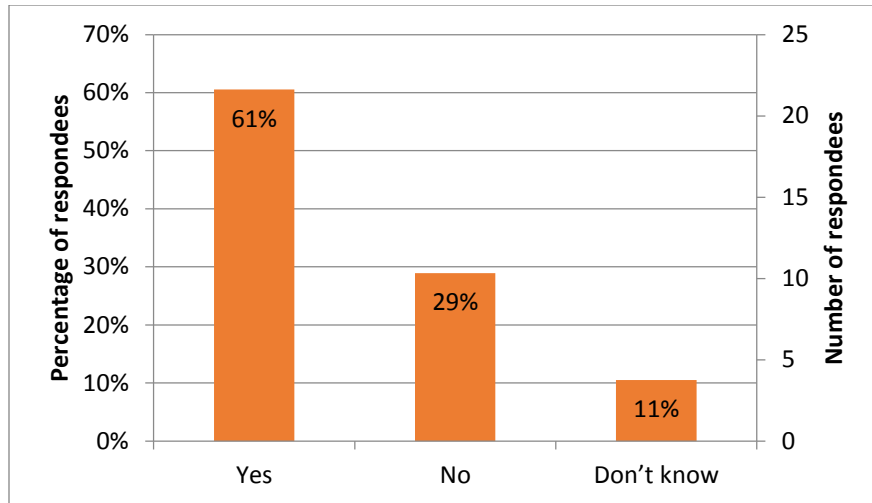


Figure (3.6)

**Conducting Periodic Health and Safety Training for Drivers
(Question 5)**

Question 6: Do all truck drivers get periodical health check?

Any material that may pose an unreasonable risk to health, safety, and property when transported is deemed hazardous, and therefore any personnel working in the immediate vicinity of this material must receive periodical health check.

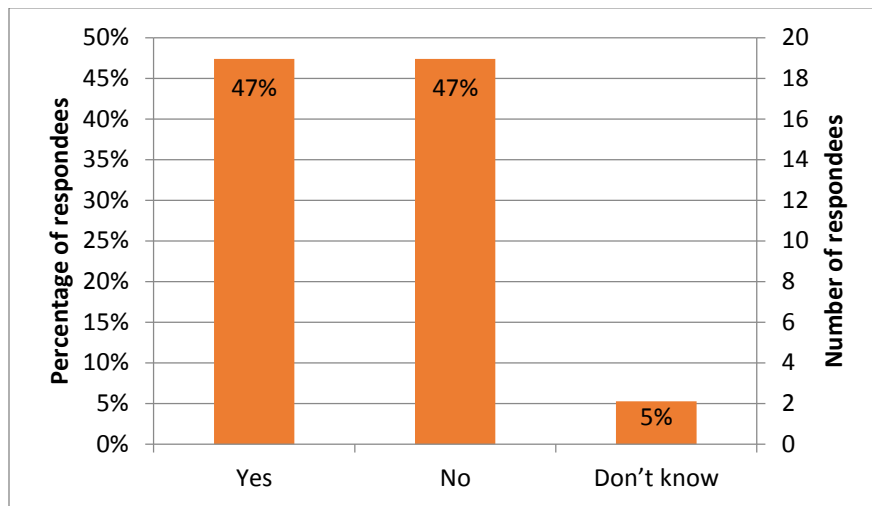


Figure (3.7)

Conducting Periodic Health Check for Drivers (Question 6)

Equal numbers of Yes and No answers were obtained from the sample regarding compliance with this aspect of periodical health check as shown above in Figure (3.7).

3.4.2 Results of perceptual questions

Questions 7 and 8: How effective is the management in considering the suggestions of drivers in route planning and route safety improvement?

The possibility of accidental release of sewage during delivery depends upon the traffic conditions or road type which is reflected in the accident statistics. Taking into consideration experienced drivers opinions when it comes to planning the route or in improving the safety route of trucking jobs, i.e. best time of using a certain route due to traffic, special events, etc., can aid greatly in prevention of accidents and spillages in crowded areas. Figures (3.8) and (3.9) represent the sample reaction to the effectiveness of the management in taking such suggestions into consideration. Twenty four percent (9 out of 38) claimed to be “very effective” in considering the suggestion of drivers in route planning, while 24% declared that taking the suggestions of drivers in route safety improvements is not applicable in their system of work.

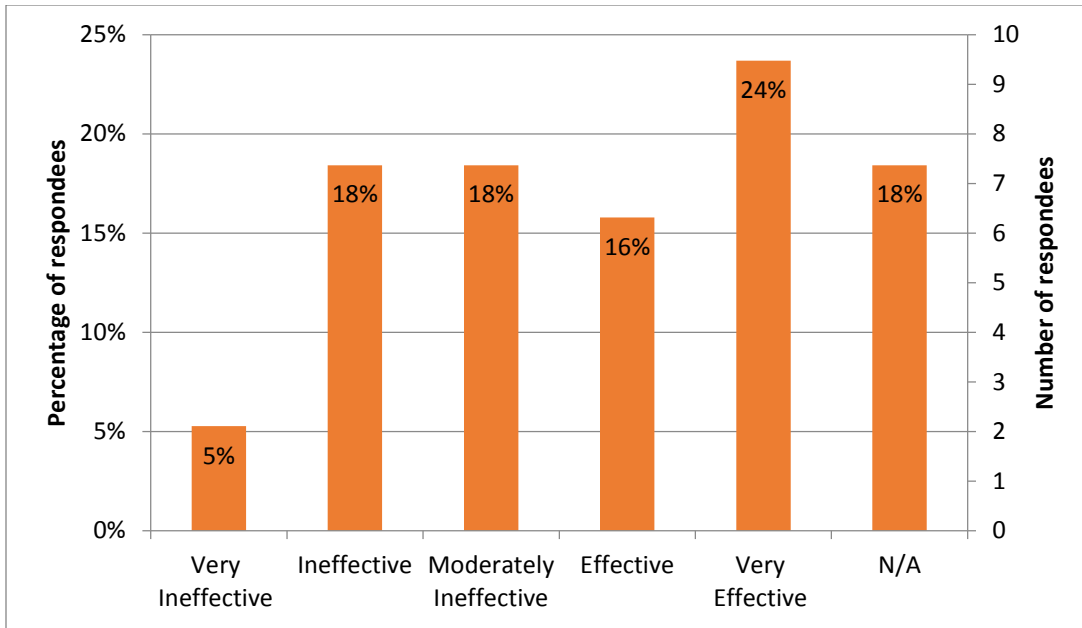


Figure (3.8)

Effective Suggestions of Route Planning by Drivers (Question 7)

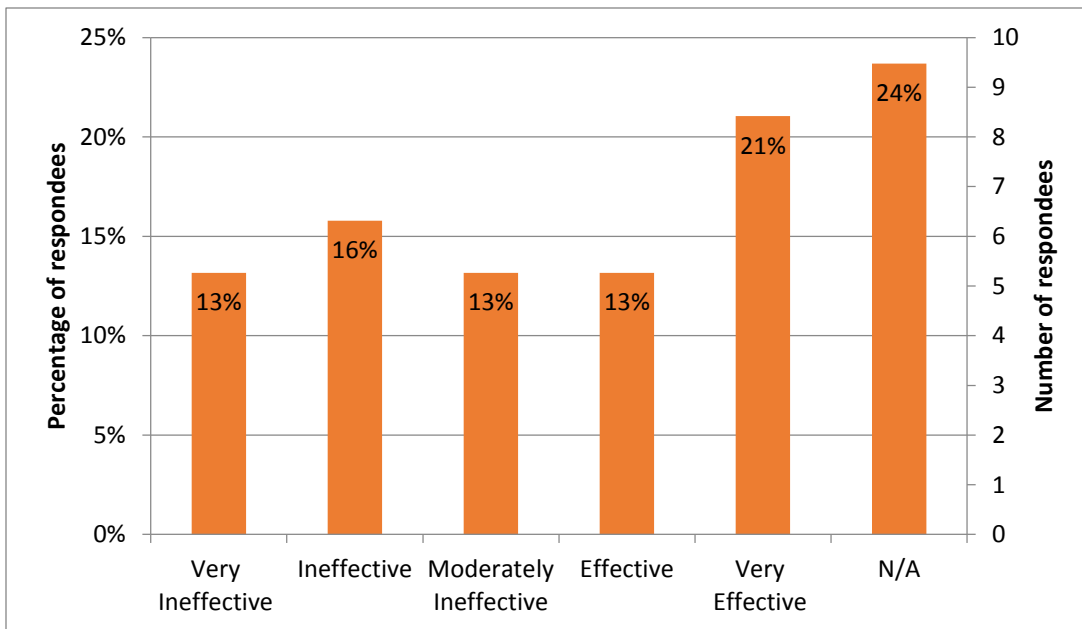


Figure (3.9)

Effective Suggestions in Route Safety Improvements by Drivers (Question 8)

Question 9: How proactive your company in applying national health and safety procedures?

Companies working in such hazardous transportation processes should strive to comply with and apply national health and safety directives to ensure safety of the employees and the public. The large majority of companies (17 out of 38) which equate to 45% of total respondents declared to be “very effective” in conforming with and applying the safety procedures as shown in Figure (3.10).

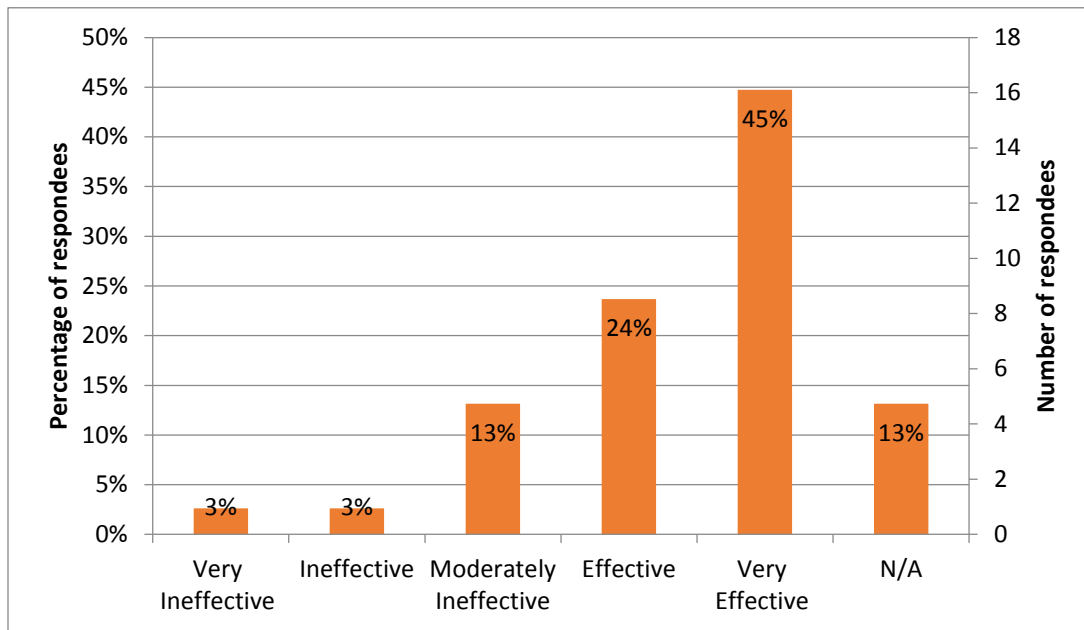


Figure (3.10)

Proactivity in Applying National Health and Safety Procedures (Question 9)

3.5 Route Planning Effectiveness Factor

Similar to the second section in the questionnaire (Company Safety Policy), data collection for Section 3 (Journey/Route Planning) is conducted by asking the sample companies to answer a series of objective questions (Yes or No) in the first part of the section and a perceptual (scaled) question in the second part of the section.

The objective questions in this section concentrated on extracting answers regarding aspects of route journey management plan which may include practices such as: consideration of traffic accidents' records during route planning; clear definition of the route; identification of hazards; completion a targeted number of jobs per day while making efforts to reduce the number of journeys. The second part of the section is a single perceptual question which aims to figure out the extent of effectiveness of the communications techniques applied between the truck drivers and the central operation room during the journeys. Below are the survey's results for the first section.

3.5.1 Results of objective questions

Question 1: Does the company have a route/journey management plan?

Planning the safest, fastest and shortest routes for sewage trucking journeys from catchment areas to sewage treatment plants would not become possible or very effective if the trucking company does not have a route journey management plan in place.

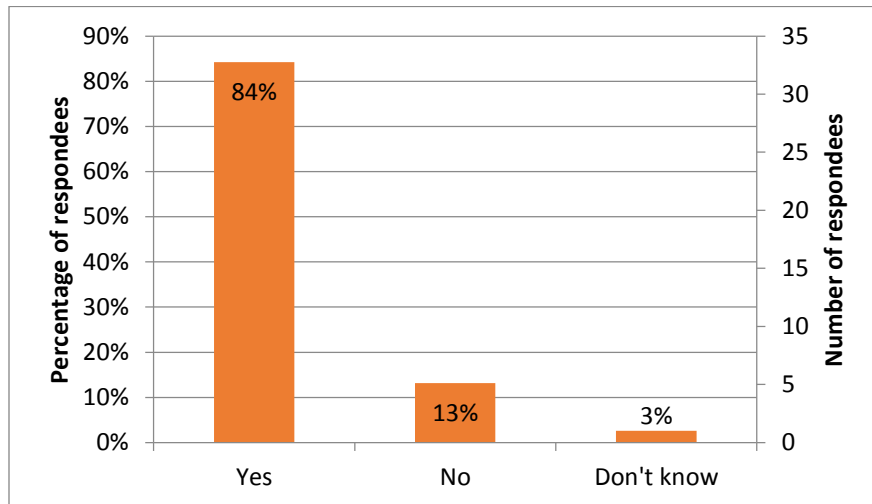


Figure (3.11)

Availability of Route/Journey Management Plan (Question 1)

The majority of companies, 84% of respondents claimed that they have a route/journey management plan as shown in Figure (3.11).

Question 2: Is the route of travel decided according to traffic department accident statistics?

Accessing and using the governmental Traffic Department's accident records could help in pointing out to sewage trucking companies which routes to avoid due to high records of accidents. A large number of respondents, twenty nine (76%) out of the thirty eight companies who replied, declared that they do not plan the routes based on the traffic accident records as shown in Figure (3.12).

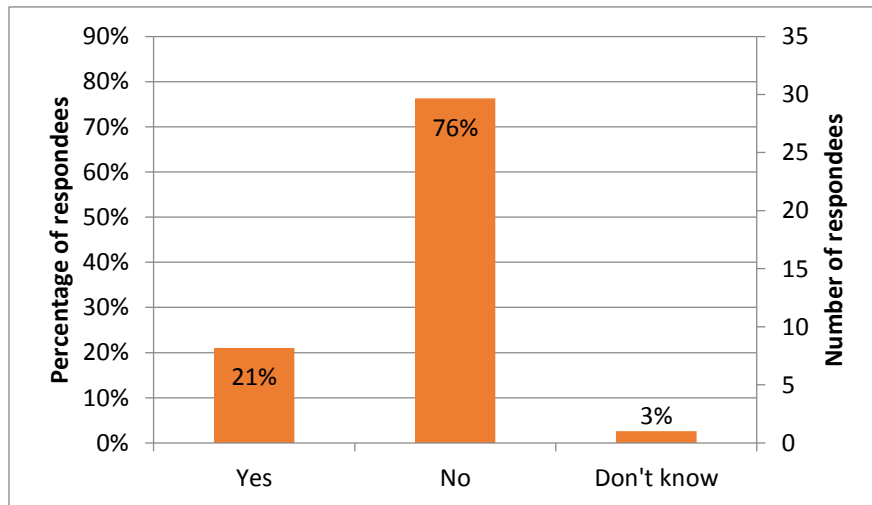


Figure (3.12)

Using of Accident Statistic in Route Planning (Question 2)

Question 3: Have the company a set job completion target per day?

Running to a strict target of jobs completion per day could lead the drivers not to abide and alter the planned routes in order to meet this target.

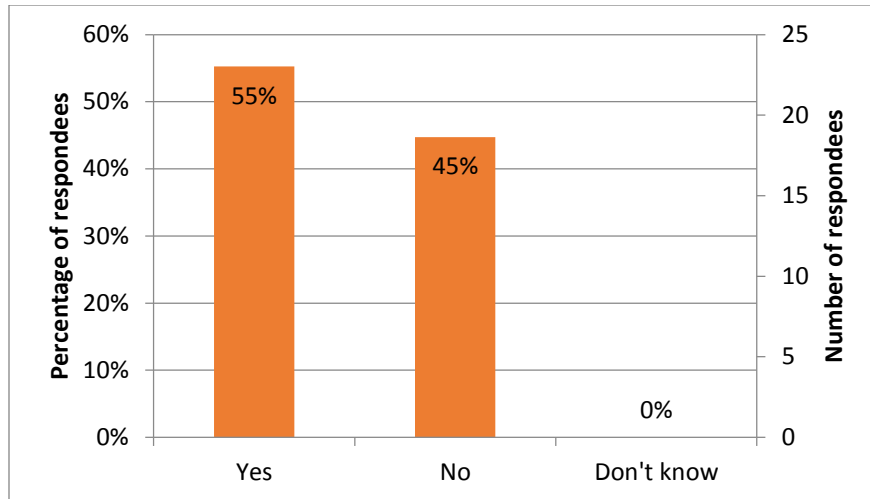


Figure (3.13)

Completing the Target No. of Journeys per Day (Question 3)

Almost an equal number of respondees replied differently to this question. Fifty five percent (21 out of 38) replied with Yes and forty five percent (17 out of 38) replied that they do not have a job completion target per day as shown in Figure (3.13).

Question 4: Are all journeys subject to management approval?

Having all journeys approved by the management prior to conducting them, ensures that the route/journey planning system is applied and adhered to. Journeys conducted without managerial approval are not accounted for and could lead to undesirable consequences. As shown in Figure (3.14), 97% of the respondees (37 out of 38) declared that all journeys made are pre-approved by the management company.

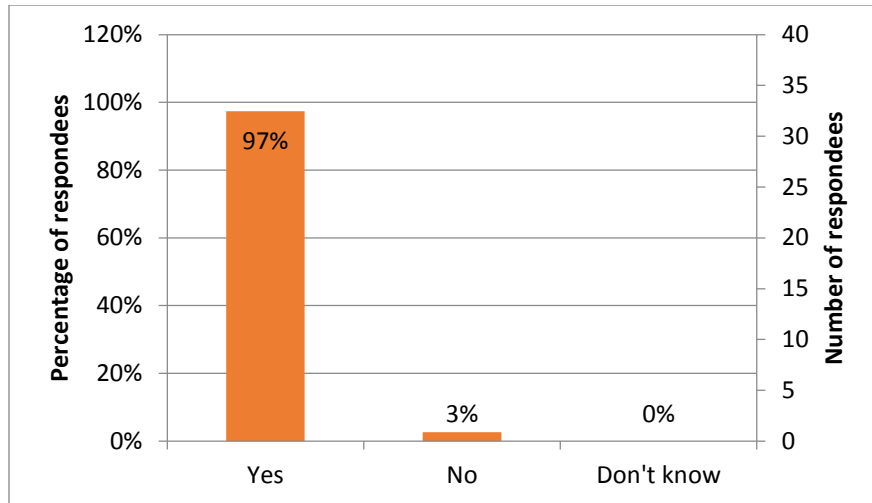


Figure (3.14)

Subjecting all Journeys to Management Approval Day (Question 4)

Question 5: Are efforts being made to reduce the number of journey to complete jobs?

The majority of respondees (58%) do not account for the number of journeys made to complete a sewage trucking job, while 39% (14 out of 38) do put in effort to reduce the number of journeys and therefore reducing the possible risk imposed on the environment. Figure (3.15) illustrates these findings.

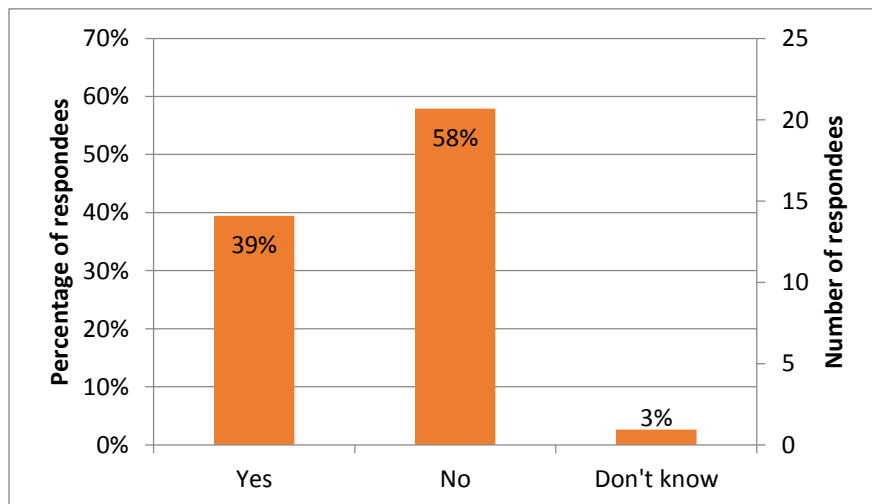


Figure (3.15)

Imposing Efforts to Reduce the No. of Journeys per Job (Question 5)

Question 6: Is the route clearly defined and mapped?

By establishing appropriate truck routes designed with input from both the trucking company and the municipality, this can help in ensuring that mobility for all roadway users, and sewage trucking can move safely and efficiently and the traffic is not affected greatly.

Figure (3.16) illustrates how the companies responded to whether or not having defined and clear routes for trucking journeys. Fifty five percent (22 out of 38) replied with No answer, while 42% (16 out of 38) replied with Yes answer.

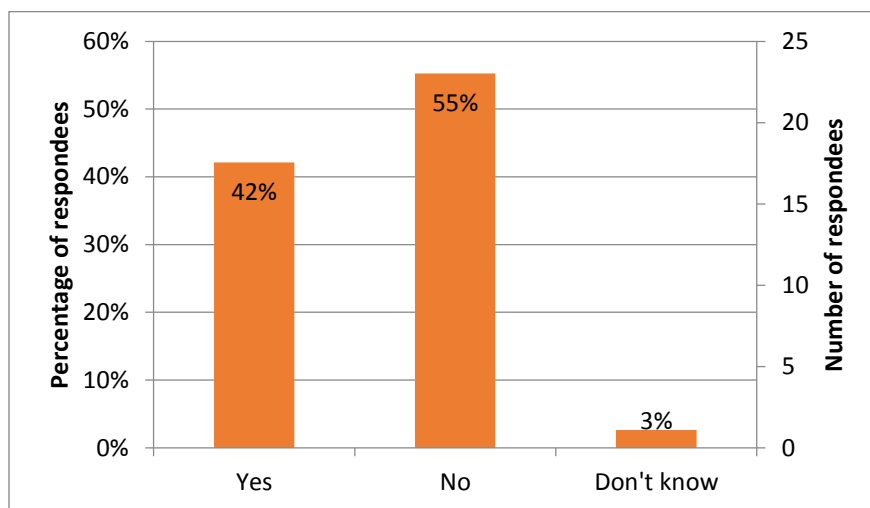


Figure (3.16)

Clearly Defined and Mapped Routes (Question 6)

Question 7: Are potential hazards in the route identified?

Trucks carrying hazardous material should not follow routes that are deemed dangerous for such loads. Fifty eight percent of respondents declared that they do not identify routes with such risks, while 37% of the respondents do carry out such assessment of hazards in routes as shown in Figure (3.17).

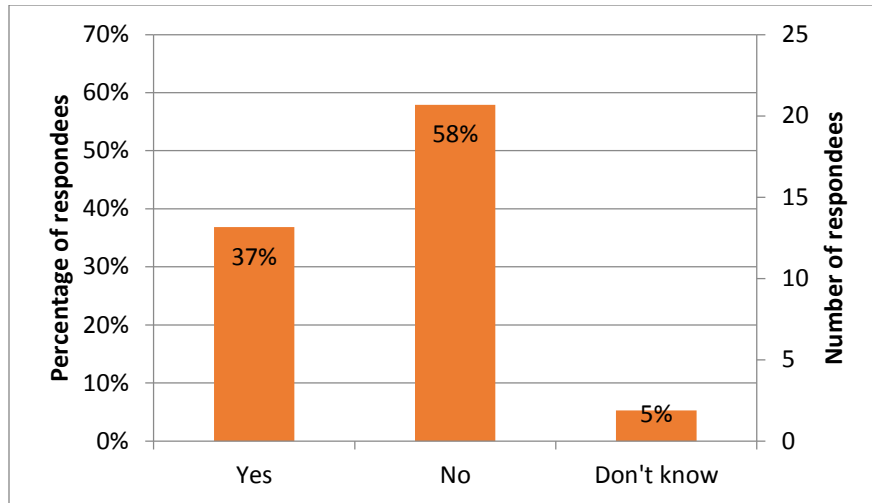


Figure (3.17)

Identifying Potential Hazards in the Route (Question 7)

3.5.2 Result of perceptual question

Question 8: How effective is your communications techniques between the trucks and the operations center during the journey?

Some of the latest technological devise for tracking vehicles can be used as a technique to determine and track its precise location. The recorded location data can be stored within the tracking unit, or it may be transmitted to a central location data base. In replies to the question regarding effectiveness of use of communication techniques, seventy one percent of the sample companies (27 out of 38) claimed to have “very effective” / “ effective” communications between the trucks and the operation center during the journey as shown in Figure (3.18).

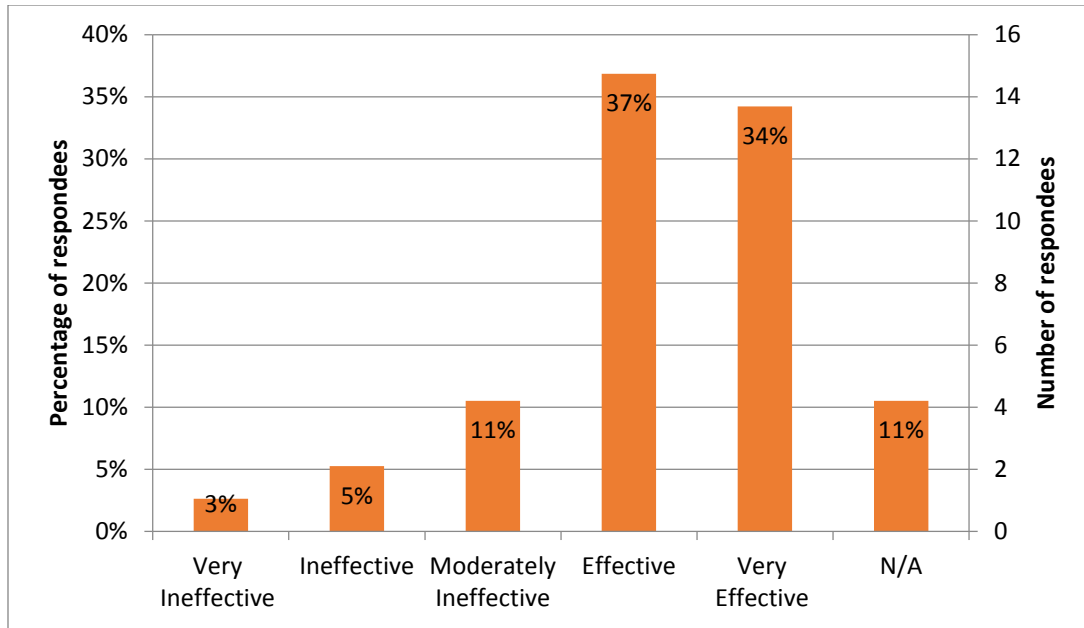


Figure (3.18)

Communication Techniques between the Trucks and the Operations Center During the Journey (Question 8)

3.6 Accidents Management Factor

The first part of Section 4 of Accidents Management factor is completed by answering a series of Yes or No type questions (objective questions) regarding the availability of accident records including spillage incidents, and the provision of accident recovery and investigation procedures.

The second part of the section is in the form of scaled answer questions (perceptual questions). These questions are aimed to work out how effective the company's procedures in ensuring that maximum loads of trucks are not exceeded, and the availability of collection and delivery time logs and these communicated to the central operations. Also, a question is asked regarding how effective the company's vehicles inspection and assignment procedures are. Below are the survey's results for the first part.

3.6.1 Results of objective questions

Question 1: Does the company have written accident records?

The information provided through recording enables the management's safety committee to identify where and how the risks arise, and to investigate serious accidents. The trucking companies must maintain an accident register containing the accident information. The majority (45%) of respondents declared that they do not have written accident records as shown in Figure (3.19).

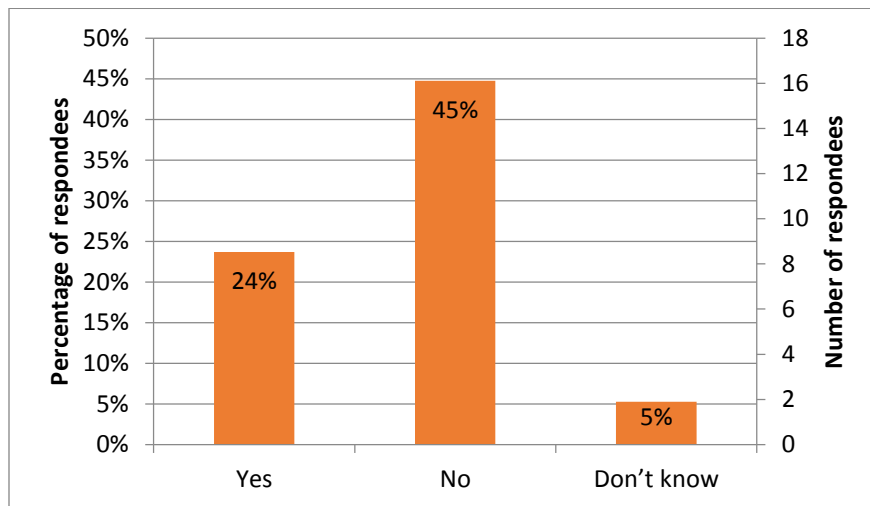


Figure (3.19)

Availability of Written Accidents Records (Question 1)

Question 2: Does the company have written accident recovery procedures?

Recovery procedures are designed to restore the company to "normal" operations after a major incident. An accident recovery procedure identifies lines of authority and responsibility, establishes proper reporting and communication procedures, and describes an action plan to be implemented in the event of an accident. Twenty companies out of the respondees, which

represent the majority, stated that they do not have written accident recovery procedures as shown in Figure (3.20).

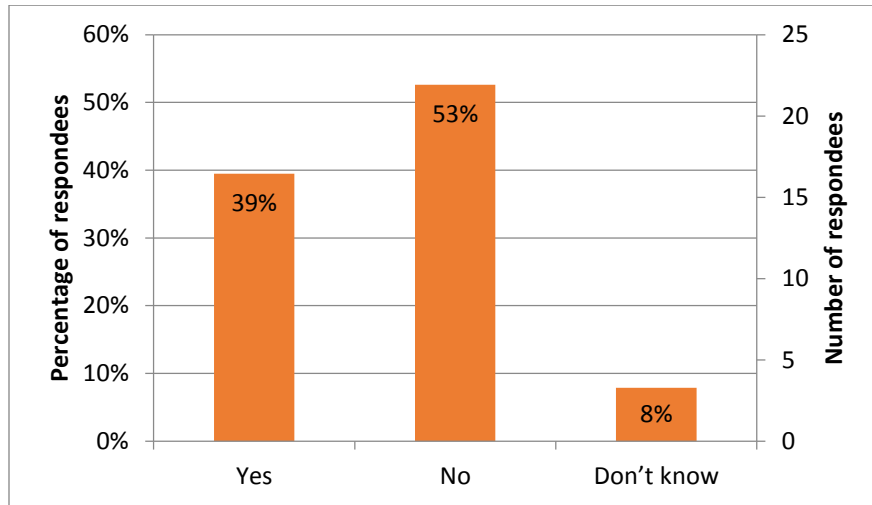


Figure (3.20)

Availability of Written Accident Recovery Procedures (Question 2)

Question 3: Are accident investigation procedures in place?

It is a good practice policy for sewage trucking companies to thoroughly investigate whether or not a hazard occurred as a result of an accident. The purpose of the investigation is to find out the causes of the accident, and in particular, the root causes, so that corrective measures can be put in place to prevent similar occurrences. The majority (82%) of respondents declared that they implement investigation procedures as shown in Figure (3.21).

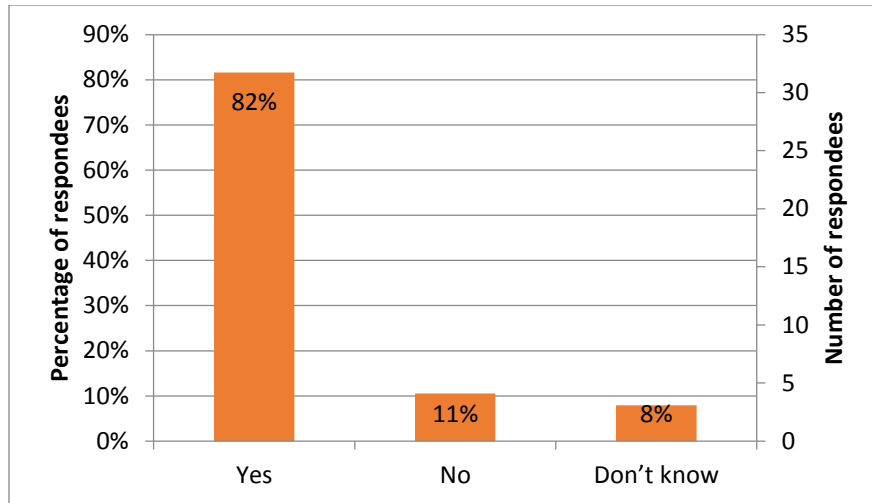


Figure (3.21)

Availability of Accident Investigation Procedures (Question 3)

Question 4: Does the company have records of spillage incidents?

Spills have the potential to cause severe environmental damage. Recording spill incidents is a good practice and can help the company learn and improve its Health, Safety and Environmental (EHS) Plan. By reporting small spills and establishing and maintaining a good relationship with regulatory bodies, the company has a better chance of not being blamed for unreported spills, small or large, for which the company is not responsible. As the results show in Figure (3.22), 53% of the respondents replied that they do not have records of spillage incidents.

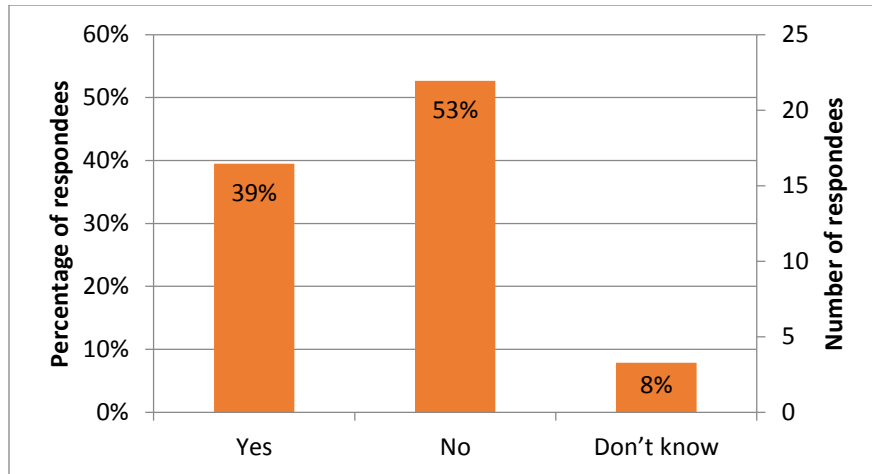


Figure (3.22)

Availability of Records of Spillage Incidents (Question 4)

Question 5: Does the company believe that spillage accidents have a direct impact on the environment?

This question is to reflect the sewage trucking companies' awareness regarding their responsibilities towards protecting the environment while conducting their business. The clear majority, 87% of respondents are aware of the impact of the spillage accidents on the environment as shown in Figure (3.23).

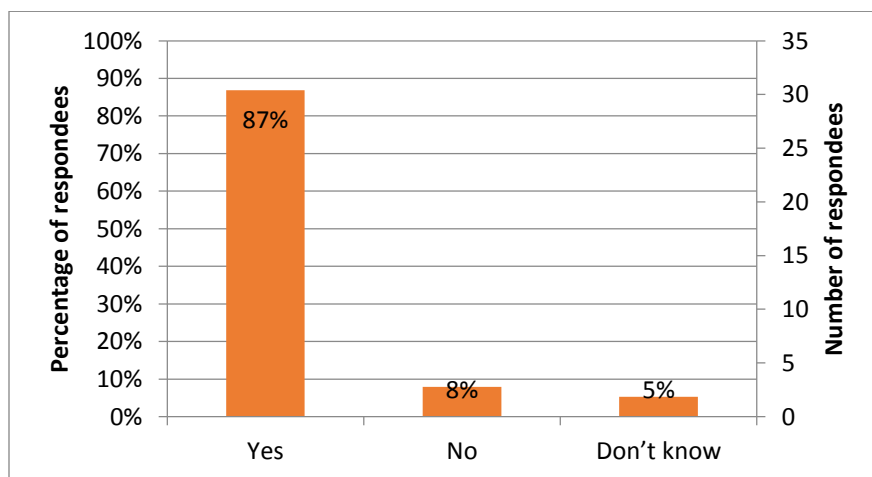


Figure (3.23)

Impact of Spillage Accidents on the Environment (Question 5)

3.6.2 Results of perceptual questions

Question 6: How effective are the company's procedures in ensuring that maximum loads of the truck are not surpassed?

As the result displayed in Figure (3.24) below shows the large majority of companies (20 out of 38), i.e. 53% of total respondents, declared that having procedures to keep the maximum loads in-check, are not applicable. Therefore, the maximum load is not adhered to during journeys.

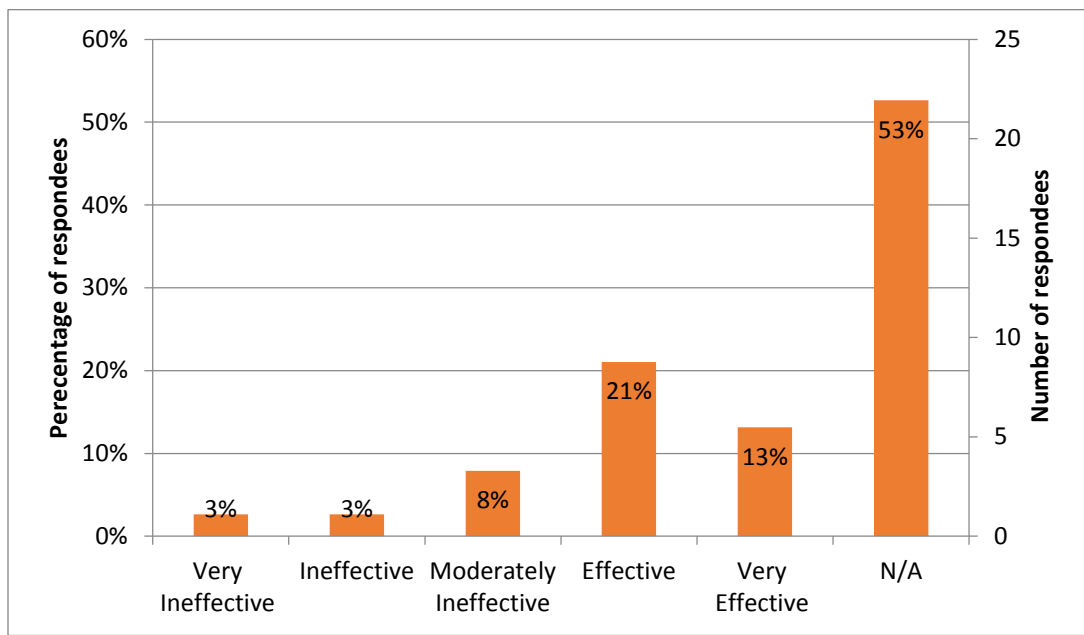


Figure (3.24)

Effective Company's procedures in Ensuring that Maximum Loads of the Truck are not Surpassed (Question 6)

Question 7: How effective is the company's vehicles inspection and assignment procedures?

Assigning certain type of vehicles for certain routes/jobs (e.g. older vehicles for small loads or shorter distances) could be considered good practice to

manage the prevention of accident. Forty seven percent of respondees declared their procedures are effective in this regard as shown in Figure (3.25).

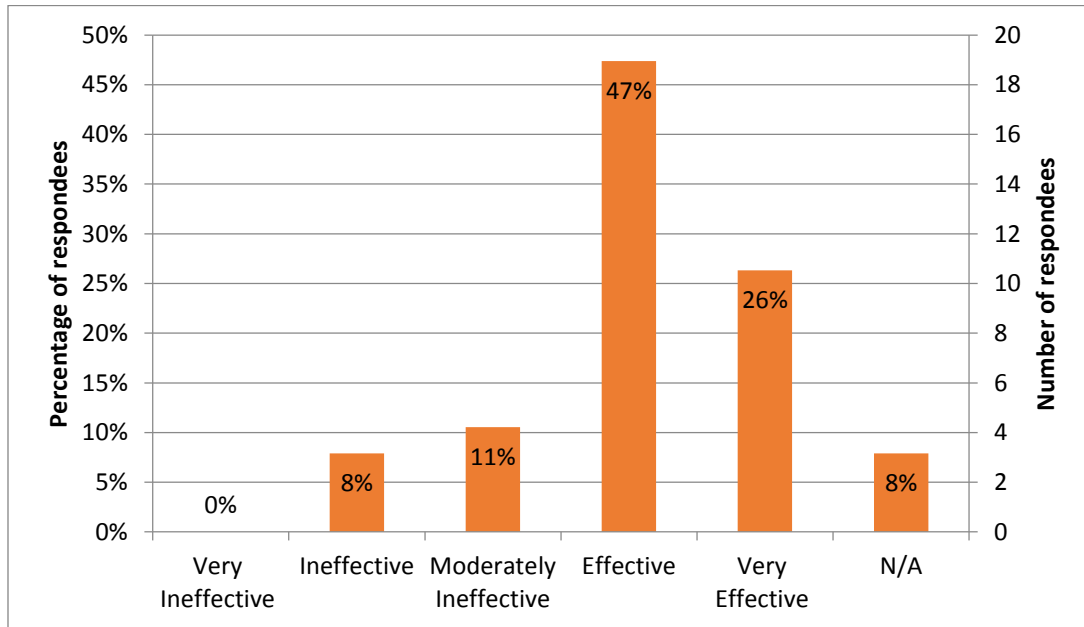


Figure (3.25)

Effective Company's Vehicles Inspection and Assignment Procedures (Question 7)

Question 8: Are collection and delivery times logged and communicated with head office?

Maintaining a register to record dispatch and delivery times of trucking journeys could aid in monitoring truck journeys for accidents if a journey takes longer than anticipated. Sixty three percent (24 out of 38) of respondees declared that the logging of collection and delivery times are maintained and communicated to head office as shown in Figure (3.26).

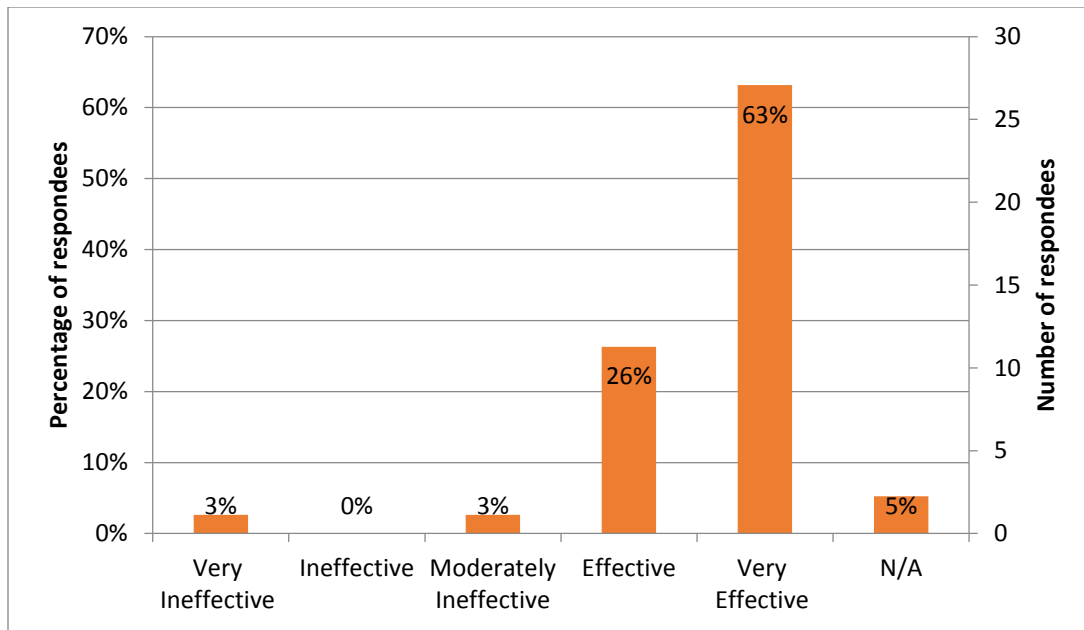


Figure (3.26)

Availability of Collection and Delivery Time Logs and Communication with Head Office (Question 8)

3.7 Vehicles Reliability Factor

In this section only objective questions were used in order to collect the data for analysis of vehicle reliability factor. In this regard, a series of questions covered the vehicle periodical inspections, availability of safety policy and procedure in the vehicle, and the provision of vehicle spill recovery plan and pre-trip vehicle check list. Below are the survey's results of this section.

3.7.1 Results of objective questions

Question 1: Are all vehicles inspected periodically?

Establishing a vehicle inspection and preventive maintenance program on a time or mileage basis and keeping records to substantiate these activities is a good indicator to enable the trucking companies to monitor vehicle

conditions and keep it to the highest possible standard. The majority (97%) of respondents declared that their vehicles are inspected periodically as shown in Figure (3.27). This question also had a second part to it concerned with the frequency of how often such vehicles are checked. The majority of the “Yes” responses declared inspection were held on weekly basis.

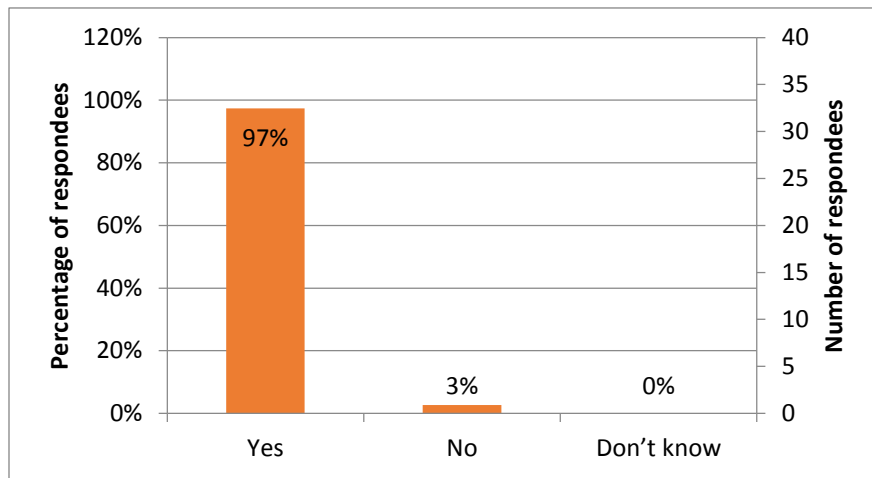


Figure (3.27)

Vehicle Periodical Inspections (Question 1)

Question 2: Do all vehicles contain a copy of the safety policy and procedures?

The purpose of provision a copy of safety policy and procedures in the vehicle is to assure that each employee who operates a vehicle maintains acceptable standards of proficiency and safety. The majority (66%) of respondents declared that they do not have a copy of the safety policy and procedures in their vehicles as shown in Figure (3.28).

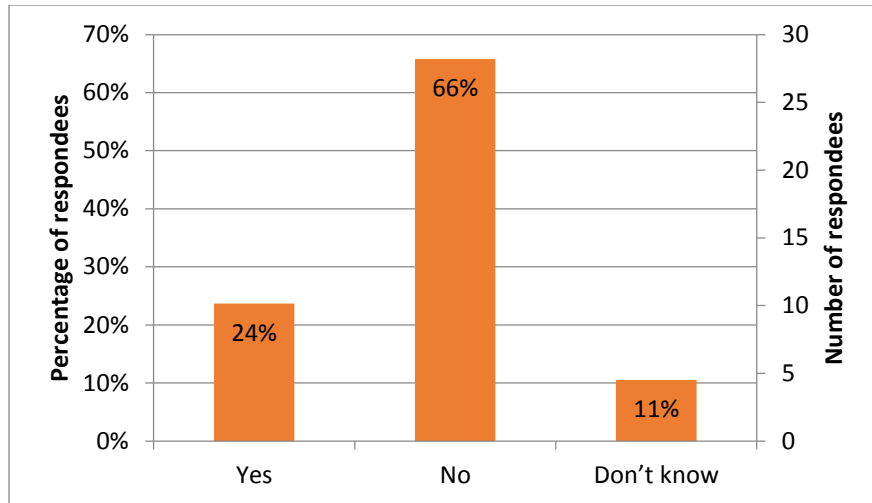


Figure (3.28)

Availability of Safety Policy and Procedure in Vehicle (Question 2)

Question 3: Does the company have a vehicle spill recovery plan?

Planning for a sewage spill emergency helps in minimizing potential danger to human health and environment by ensuring a timely and coordinated response. Eighteen companies out of the sample stated that they have a vehicle spill recovery plan as shown in Figure (3.29).

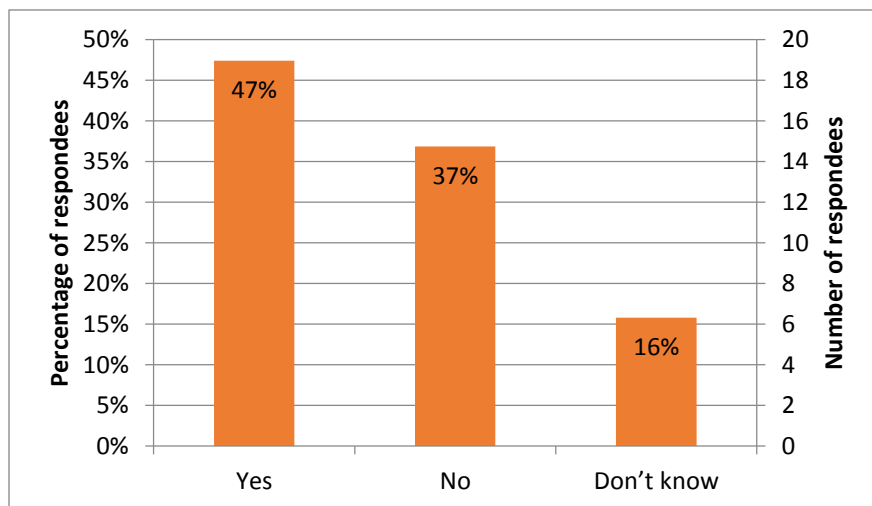


Figure (3.29)

Availability of Vehicle Spill Recovery Plan (Question 3)

Question 4: Do you have a pre-trip vehicles check list?

The vehicle operator should ensure that vehicles used for the collection of sewage are fit for purpose, roadworthy, and incorporate essential safety features. Daily condition checks should be carried out on the vehicle. Sixty one percent (23 out of 38) of respondents declared that they do not have a pre-trip check list as shown in Figure (3.30).

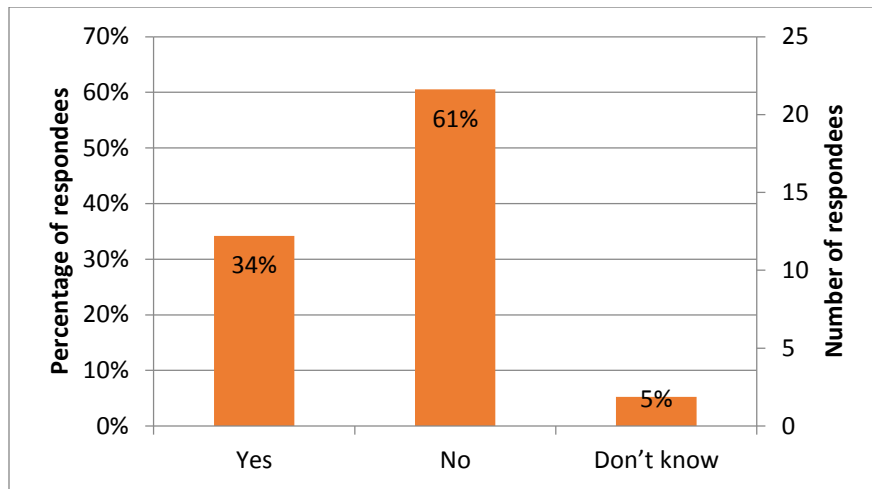


Figure (3.30)

Availability of Pre-trip Vehicle Check list (Question 4)

3.8 Operational and Maintenance Costs

In this section, a series of questions were used in order to collect the data for analysis of operational and maintenance costs. The operational costs related questions include fleet size and model, driver's salaries, experience, age and working hours per day. The maintenance costs related questions include driving practices, frequency of vehicle maintenance and type of maintenance. Below are the survey's results of this section.

3.8.1 Results of operational costs questions

Question 1: How large do you consider your fleet size?

The fleet size of a company is a direct indicator to how much operational and maintenance costs a company will shoulder. It is shown in Figure (3.31) that a large number of companies (68%) declared that they have a small fleet size.

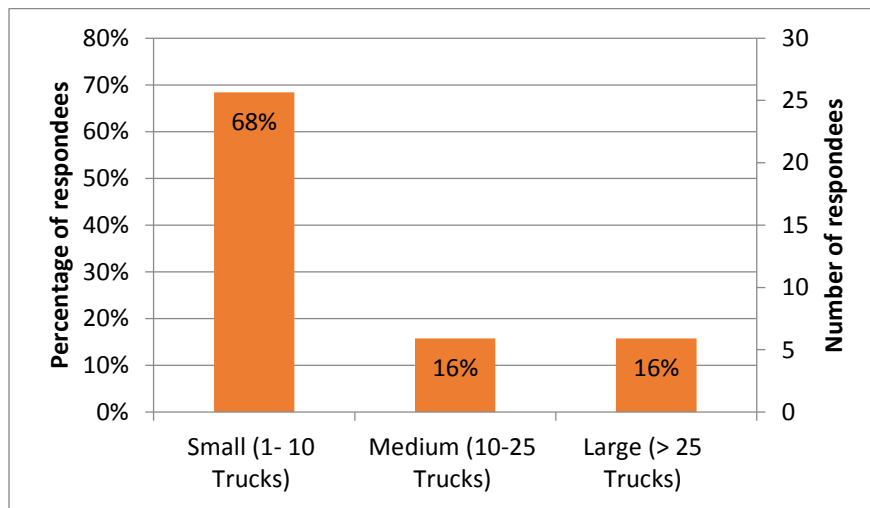


Figure (3.31)

Fleet Size (Question 1)

Question 2: How old do you consider your fleet model?

The age of the fleet can result in increased or decreased costs depending on how old or how recent it is. Thirty four companies declared they have a recent fleet model as illustrated in Figure (3.32).

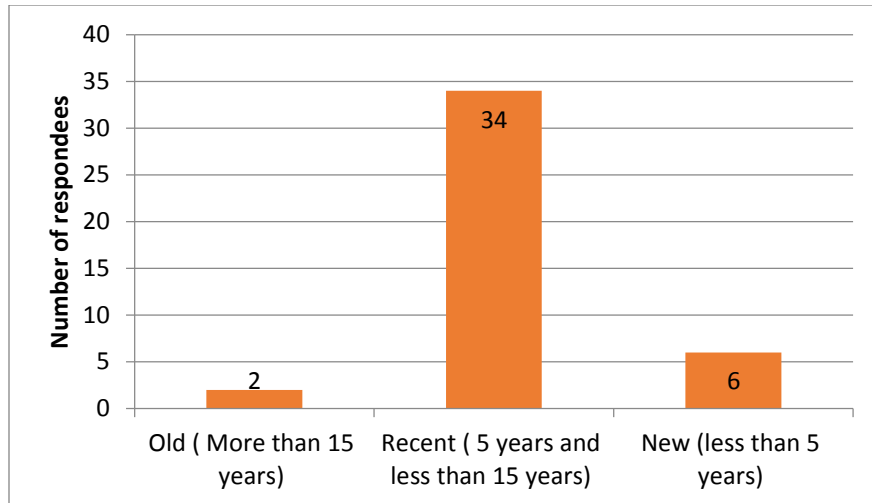


Figure (3.32)

Fleet Model (Question 2)

Question 3: How do you consider your drivers' salaries?

The driver salary is one of the main costs of a company's expenditure. The large majority of companies' drivers (66%) are paying low salaries, and 24% are within the average range as shown in Figure (3.33). Note that 11% of the respondents did not state the salary range.

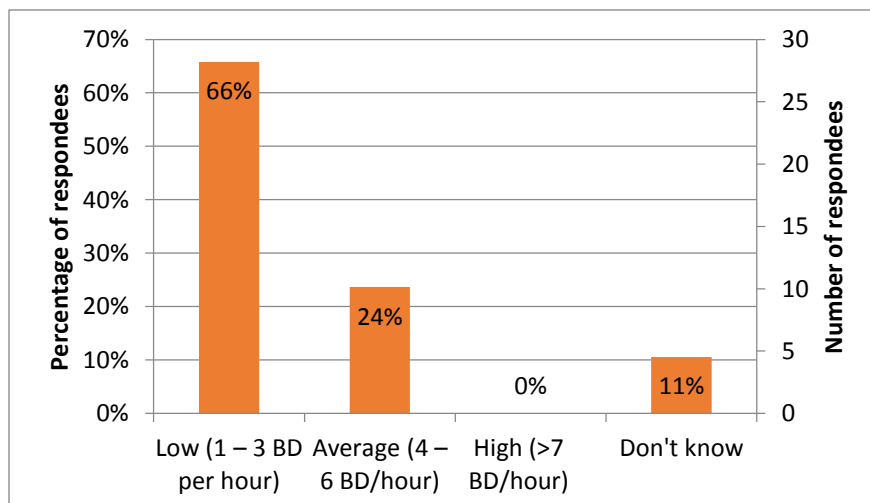


Figure (3.33)

Driver Salaries (Question 3)

Question 4: Please state the averages for the driver's years of experience, age and working hours per day.

Driver's bio data could contribute towards costs and/or safety. The averages shown in Figure (3.34) are obtained from the sample companies.

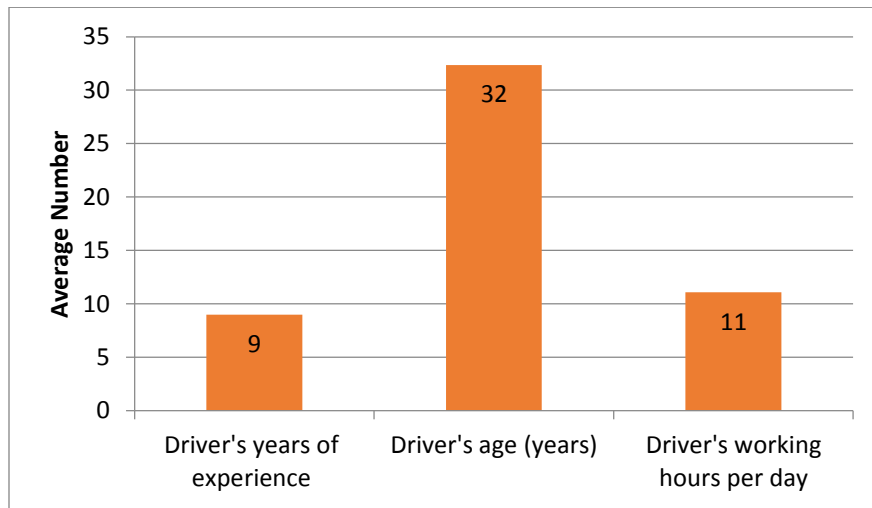


Figure (3.34)

Driver's Bio Data Averages (Question 4)

Question 5: Does the company have a maximum tank load policy for jobs?

Maximum tank load capacity could have an impact on company's costs in terms of affecting the number of journeys made per trucking job. Sixty six percent of sample companies declared that they do not have maximum tank load policy as shown in Figure (3.35) below.

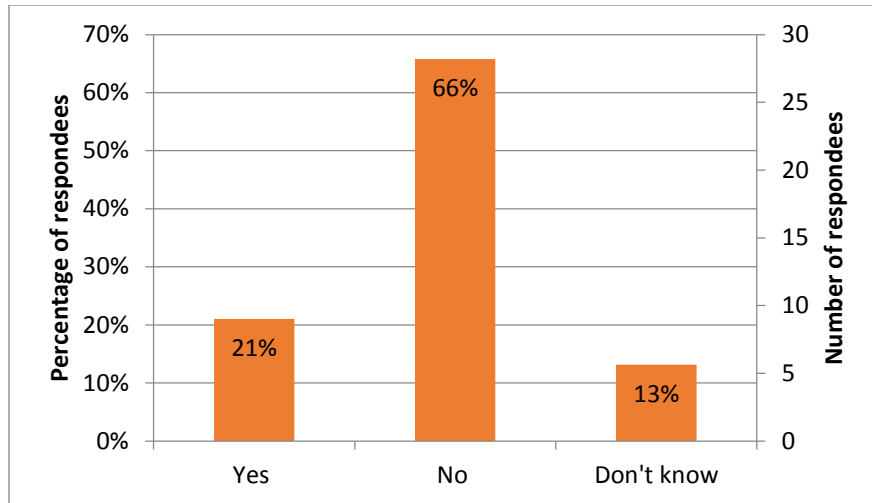


Figure (3.35)

Availability of Maximum Tank Load Policy for Jobs (Question 5)

3.8.2 Results of maintenance costs questions

Question 1: How do you consider you staff driving practices, please rate from 1 to 10.

Driving practices could play a critical role in vehicle safety and maintenance. Figure (3.36) below shows how the companies consider their staff driving practices. Thirty seven percent of companies consider their drivers to possess good driving practices.

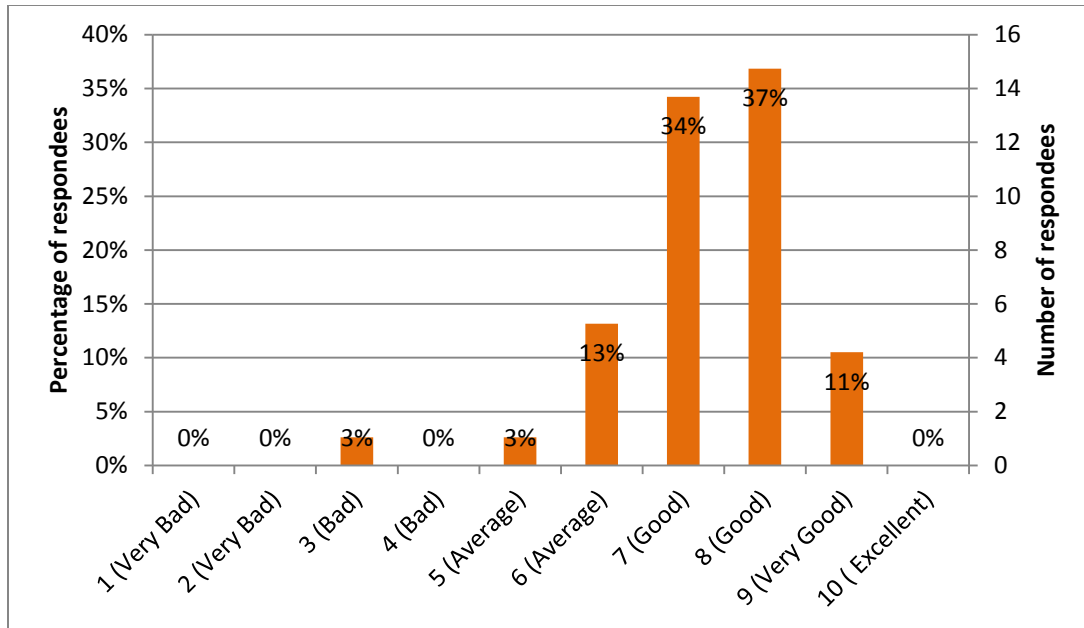


Figure (3.36)
Rating of Staff's Driving Practices (Question 1)

Question 2: How often is total maintenance carried out on trucks?

The frequency of vehicle maintenance affects both safety and cost. The lower the frequency, the lower the cost, but the higher the risk and vice versa. Twelve companies (32%) did not state the frequency of maintenance. Whereas, the most frequent servicing is carried out semi-annually by eleven companies (29%) of the respondents as shown in Figure (3.37).

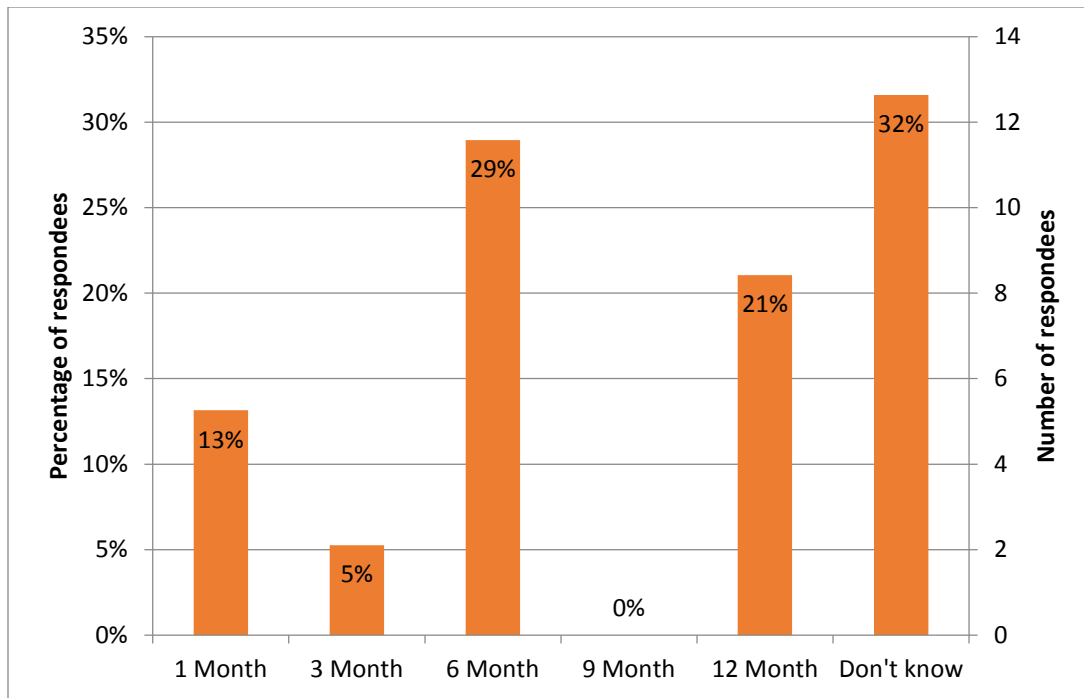


Figure (3.37)
Frequency of Vehicle Maintenance (Question 2)

Question 3 and 4: Is periodical maintenance done by service provider or in-house?

Vehicle maintenance is an integral part of the fleet safety policy. While all vehicles must be regularly maintained, however, the way in which this is carried out can vary among different sites. Some trucking companies choose to conduct vehicle maintenance in-house, whereas some outsource it. It is shown in Figure (3.38) that a large number of companies (58%) declared that they don't do the vehicle maintenance by service provider. While, a large number of companies (68%) declared that they conduct the maintenance in-house. It worth to mention that some companies do contracting for some of their vehicles and in-house for some.

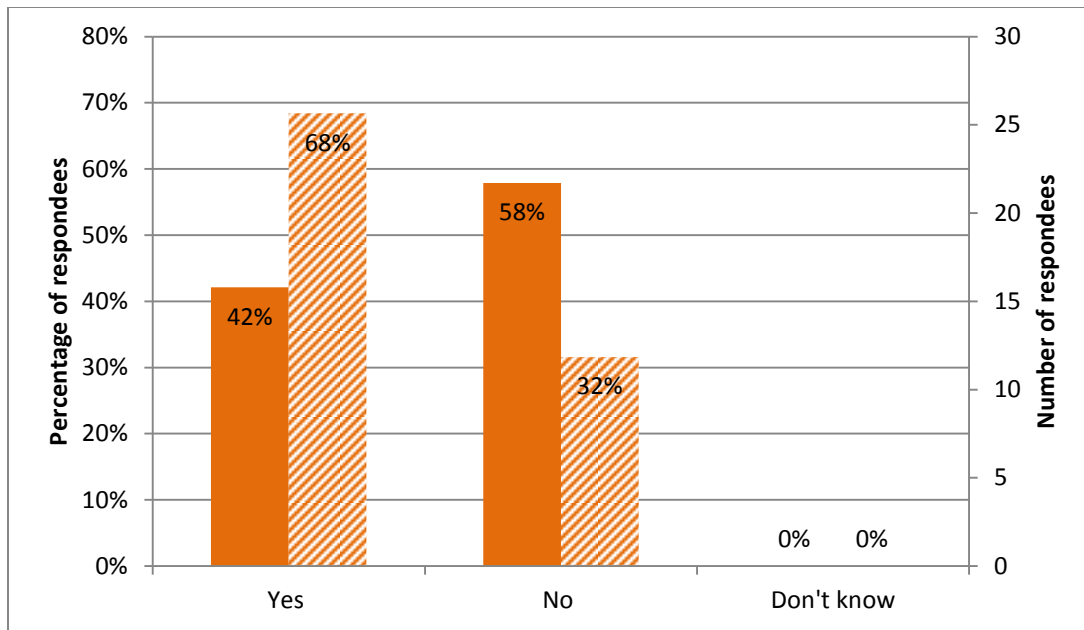


Figure (3.38)

Conducting of Periodical Vehicle Maintenance by Service Provider and In-house (Question 3 and 4)

Chapter Four

Analysis of Results and Discussion

4.1 Introduction

4.2 Analysis of Safety Policy Factor

4.3 Analysis of Route Planning Effectiveness Factor

4.4 Analysis of Accidents Management Factor

4.5 Analysis of Vehicles Reliability Factor

4.6 Summary of Objective and Perceptual Indices of the Main Factors

4.7 Analysis of Operational and Maintenance Costs

Chapter Four

Analysis of Results and Discussion

4.1 Introduction

Fifty surveys were initially sent to all the listed Sewage Trucking Service Companies in the Kingdom of Bahrain from which thirty eight responses were received back giving a response rate of 76%. To achieve the objective of this data analysis which is to evaluate the safety management of sewage trucking practices, the respondees sewage trucking companies were categorized into three sub groups according to truck fleet size (Small – less than 10 trucks, Medium – between 10 to 25 trucks and Large – greater than 25 trucks). This categorization stemmed from the answer of each respondent to the question in the survey of how they evaluated their fleet size. The response rate based on the sub grouping was as follows; out of the fifty companies approached with the questionnaire, thirty six (68%) were small companies, six (16%) were medium companies and six (16%) were large companies. The portions of each sub-group in the thirty eight responses received were as follows; twenty six (68%) were from small companies, six (16%) from medium companies and six (16%) were from large companies, as shown in Table (4.1).

Table (4.1)
Summary of Respondees Statistics

Fleet Size	Small	Medium	Large	Total	Response Rate
Total Approached	38 (76%)	6 (12%)	6 (12%)	50	76%
Total Respondees	26 (68%)	6 (16%)	6 (16%)	38	

4.2 Analysis of Safety Policy Factor

In analyzing the safety policy factor in the sub-sections to follow, an evaluation for both the objective and perceptual questions is carried out followed by determining the overall compliance of the safety policy index and the safety policy perceptual index.

4.2.1 Objective and perceptual evaluations

The frequency of answers (Yes, No or Don't know) to each objective question based on the different fleet size sub groups were listed and given a percentage weight relative to the total number of answers, as shown in Table (4.2). Also Table (4.3) is constructed with the frequencies of ratings to questions seven to nine from the three sub-groups.

Table (4.2)

Summary of Respondee to the Objective Questions for the Company Safety Policy Factor

	Yes Respondee			No Respondee			Don't know Respondee		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Question 1	16* (62%)**	6 (100%)	6 (100%)	7 (27%)	0 (0%)	0 (0%)	3 (12%)	0 (0%)	0 (0%)
Question 2	9 (35%)	6 (100%)	6 (100%)	14 (54%)	0 (0%)	0 (0%)	3 (12%)	0 (0%)	0 (0%)
Question 3	7 (27%)	4 (67%)	5 (83%)	16 (62%)	0 (0%)	0 (0%)	3 (12%)	2 (33%)	1 (17%)
Question 4	5 (19%)	5 (83%)	4 (67%)	17 (65%)	1 (17%)	2(33%)	4 (15%)	0 (0%)	0(0%)
Question 5	13 (50%)	4 (67%)	6 (100%)	10 (38%)	1(17%)	0(0%)	3 (12%)	2 (33%)	0(0%)
Question 6	10 (38%)	4 (67%)	4 (67%)	15 (58%)	1 (17%)	2(33%)	1 (4%)	1 (17%)	0(0%)

*Number of respondees ** % of respondees

Table (4.3)

**Summary of Respondee's to the Perceptual Questions for the Company
Safety Policy Factor**

	Number and Percentage of Respondee's		
Question 7	Small	Medium	Large
Very Ineffective	2 (8%)	0 (0%)	0 (0%)
Ineffective	7 (27%)	0 (0%)	0 (0%)
Moderately Ineffective	5 (19%)	1 (17%)	1 (17%)
Effective	3 (12%)	2 (33%)	1 (17%)
Very Effective	2 (8%)	3 (50%)	4 (67%)
N/A	7 (27%)	0 (0%)	0 (0%)
Question 8	Small	Medium	Large
Very Ineffective	5 (19%)	0 (0%)	0 (0%)
Ineffective	4 (15%)	1 (17%)	0 (0%)
Moderately Ineffective	3 (12%)	0 (0%)	1 (17%)
Effective	1(4%)	1 (17%)	2 (33%)
Very Effective	4 (15%)	4 (67%)	3 (50%)
N/A	9 (35%)	0 (0%)	0 (0%)
Question 9	Small	Medium	Large
Very Ineffective	0 (0%)	0 (0%)	1 (17%)
Ineffective	1 (4%)	0 (0%)	0 (0%)
Moderately Ineffective	3 (12%)	2 (33%)	0 (0%)
Effective	9 (35%)	0 (0%)	0 (0%)
Very Effective	9 (35%)	4 (67%)	4 (67%)
N/A	4 (15%)	0 (0%)	1 (17%)

Analyzing the data of Table (4.2) and (4.3) will enable validating the trueness of the replies or identifying discrepancies in replies when the answers of related questions are cross tabulated. The related questions which were deemed eligible for cross tabulation and their answers can be compared in order to work out the compliance with the safety policy are listed below and then analysed.

For question one, 62% of the Small Fleet Size companies replied Yes to having a pre-defined transport safety policy, while only 27% of these companies replied Yes to question 3 that they have established safety committees as shown in Table (4.2) above. Meanwhile, 100% of the Large Fleet sub-group replied Yes to question one of having transport safety policy and 83% of them claimed to have a safety committee establishment. Looking at these percentages for the replies to question one and question three, small differences are expected between the percentages of the two questions for each sub-group because having a pre-defined safety policy is associated with presence of a safety committee to draw up and/or follow such policies.

For question two, nine companies (35%) of the small companies replied Yes to holding periodical safety meetings while fourteen (54%) of them replied No as shown in Table (4.2) above. When this is compared to the percentages of question three where 16 small companies (62%) declared that they have no safety committee in place, it can be deduced that the replies to both question one and question three are in line with each other's. In the case of the large fleet and medium fleet companies, the situation is different. All (100%) of large companies and medium size companies claimed to hold periodical safety meetings, but in return, 83% of large companies and 67% of medium size companies claimed to have a safety committee in place. Even though, it cannot be deduced to a great extent that the safety policy is not adhered to since the percentages of the Yes replies are high enough.

In question four where the companies are questioned regarding conducting risk assessment analysis prior to trucking journeys, seventeen small size companies (65%) replied with a No and this conforms well with the fact that

seven (27%) small companies claimed to be “ineffective” in taking drivers suggestions in route planning (Question 7) and seven other small companies replied that taking drivers suggestions is “Not Applicable”. While in the case of the large and medium fleet size companies, five (83%) of medium size companies replied Yes to question four and most of their replies to question seven was for the “Effective” and “Very Effective” options. Similarly with the large fleet companies, four (67%) replied Yes to conducting risk assessment analysis prior to attending trucking orders and the majority of the large companies claimed to be “Very effective” in taking drivers suggestions in route planning as shown in Table (4.3).

4.2.2 Compliance of Safety Policy Index (CSPI)

This Index gives an explanation of how effective the company in implementing management system that ensures the compliance with safety requirements. The Compliance of the Safety Policy Index (CSPI) is based on six sub-indices (CSPI(i); $i=1, 2, 3 \dots, 6$), as shown in Table (4.4).

Table (4.4)
Safety Policy Sub-indices

Sub-index(i)	Sub-index description CSPI(i)
1	Availability of predefined transport safety program
2	Holding periodic safety meetings
3	Established safety committee
4	Conducting risk assessment analysis prior to new trucking orders
5	Conducting periodic health & safety training for drivers
6	Carrying periodical health check for drivers

The Compliance Index of SPF(i) (CSPI(i)) is established from the number of Yes responses over the sample size as shown in the Equation (4.1) below:

$$CSPI(i) = \frac{\text{No.of Yes Respondees of SPF(i)}}{\text{Sample Size}} \quad (4.1)$$

The Overall Compliance Index of SPF (OCSPI) is established by the following equation:

$$OCSPI = \frac{\sum_{i=1}^6 ISPF(i) * CSPI(i)}{\sum_{i=1}^6 ISPF(i)} \quad (4.2)$$

Where ISPF(i) is the importance of SPF(i), it is established based on the experts' questionnaire such that the highest importance value is equal to 6, and the lowest value is 1.

The numbers of Yes responses collected for the sub-factors of the first main factor, i.e. the Safety Policy, and their importance ratings are shown in Table (4.5).

For example, calculation of the compliance of the first sub-index (Availability of pre-defined transport safety program) is as follows:

$$CSPI(1) = \frac{28}{38} = 0.74$$

Similarly, the compliance of other indices are calculated and shown in Table (4.5).

Table (4.5)
Number of Responses and Importance Ratings of the Safety Policy Sub-factors

Sub-factor(i)	Safety Policy Sub-factor description	No. of Yes	Compliance Sub-index	Import. Rating
1	Availability of predefined transport safety program	28	0.74	5
2	Holding periodic safety meetings	21	0.55	3
3	Established safety committee	16	0.42	4
4	Conducting risk assessment analysis prior to new trucking orders	14	0.37	4
5	Conducting periodic health & safety training for drivers	23	0.61	4
6	Carrying periodical health check for drivers	18	0.47	2
Total No. of Yes Respondents		120		

The calculation of the overall compliance of safety policy index (OCSPI) using Equation (4.2) is as follows:

$$OCSPI = \frac{5 \times 0.74 + 3 \times 0.55 + 4 \times 0.42 + 4 \times 0.37 + 4 \times 0.61 + 2 \times 0.47}{5 + 3 + 4 + 4 + 4 + 2} = 0.539$$

Thus, the overall compliance of the safety policy index is 53.9%.

4.2.3 Perceptual indices

In addition to the compliance of safety policy index, three perceptual indices for safety policy (SPPI(i); i=1,2,3) are defined for the following three perceptual indicators (an index for each indicator):

- 1- Effective route planning suggestions by drivers
- 2- Effective suggestions in route safety improvements by drivers
- 3- Proactivity in applying national health and safety procedures

The determination of the Safety Policy Perceptual Index SPPI(i) is performed by using Equation (4.3):

$$SPPI(i) = \frac{\sum_{j=1}^5 w_j * f_{ij}}{5 * Sample\ size} \quad (4.3)$$

Where f_{ij} is the frequency of index i for rating w_j as established by the experts; w_j is the rating scale in the questionnaire ($w_1=1$ for very ineffective; $w_2=2$ for ineffective; $w_3=3$ for moderately ineffective; $w_4=4$ for effective; $w_5=5$ for very effective); and sample size is the number of trucking companies surveyed, which is 38.

The weight of each perceptual indicator is calculated by using Equation (4.4):

$$WSPPI(i) = \frac{SPPI(i)}{\sum_{i=1}^3 SPPI(i)} \quad (4.4)$$

Finally, the Overall Safety Policy Perceptual Index (OSPPI) is determined by using Equation (4.5):

$$OSPPI = \sum_{i=1}^3 SPPI(i) * WSPPI(i) \quad (4.5)$$

Where WSPPI(i) is the weight of the safety policy perceptual indicator (i), (i= 1,2, 3).

For example, the numbers of responses collected for the first main factor indicators, which is the Safety Policy, are shown in Table (4.6).

Table (4.6)**Number of Responses of the Safety Policy Indicators**

No.	Safety Policy Perceptual Indicator	No. of Respondees					
		Rating Scale (w_j)					NA
		1	2	3	4	5	
1	Effective route planning suggestions by drivers	2	7	7	6	9	7
2	Effective suggestions in route safety improvements by drivers	5	6	5	5	8	9
3	Proactivity in applying national health and safety procedures	1	1	5	9	17	5

1=Very Ineffective; 2=Ineffective; 3=Moderately Ineffective; 4=Effective; and 5=Very Effective.

The calculation of the perceptual index of the first Safety Policy Indicator by using Equation (4.3) is as follows:

$$SPPI(1) = \frac{(2*1+7*2+7*3+6*4+9*5)}{5*38} = 0.558;$$

For the second indicator is:

$$SPPI(2) = \frac{(5*1+6*2+5*3+5*4+8*5)}{5*38} = 0.484;$$

And for the third indicator is:

$$SPPI(3) = \frac{(1*1+1*2+5*3+9*4+17*5)}{5*38} = 0.732.$$

The calculation of the weight of the first Safety Policy Perceptual Indicator by using Equation (4.4) is as follows:

$$\text{WSPPI}(1) = \frac{0.558}{0.558 + 0.484 + 0.732} = 0.315;$$

For the second indicator is:

$$\text{WSPPI}(2) = \frac{0.484}{0.558 + 0.484 + 0.732} = 0.273;$$

And for the third indicator is:

$$\text{WSPPI}(3) = \frac{0.732}{0.558 + 0.484 + 0.732} = 0.412.$$

The Overall Safety Policy Perceptual Index is obtained by using Equation (4.5):

$$\text{OSPPI} = 0.558 * 0.315 + 0.484 * 0.273 + 0.732 * 0.412 = 0.609.$$

Thus, the overall safety policy perceptual index is 60.9%.

4.3 Analysis of Route Planning Effectiveness Factor

In analyzing the route planning effectiveness factor in the sub-sections to follow, an evaluation for both the objective and perceptual questions is carried out followed by determining the overall effectiveness of the route planning index and the route planning perceptual index.

4.3.1 Objective and perceptual evaluations

In order to yield credibility to the answers received for Section 3 (Journey/Route Planning), cross tabulating and referencing the related questions are carried out. Table (4.7) summarizing the replies to the objective questions in terms of counts and percentages and Table (4.8) summarizing the replies to the perceptual question are used for this cross-tabulation.

Table (4.7)**Summary of Responsees to the Objective Questions for the Route Planning Effectiveness Factor**

	Yes Responsees			No Responsees			Don't know Responsees		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Question 1	21* (81%)**	6 (100%)	5 (83%)	4 (15%)	0 (0%)	1 (17%)	1 (4%)	0 (0%)	0 (0%)
Question 2	0 (0%)	4 (67%)	4 (67%)	25 (96%)	2 (33%)	2 (33%)	1 (4%)	0 (0%)	0 (0%)
Question 3	11 (42%)	4 (67%)	6 (100%)	15 (58%)	2 (33%)	0 (0%)	1 (4%)	0 (0%)	0 (0%)
Question 4	16 (62%)	6 (100%)	6 (100%)	1 (4%)	0 (0%)	0 (0%)	9 (35%)	0 (0%)	0(0%)
Question 5	5 (19%)	6 (100%)	4 (67%)	19 (73%)	0 (0%)	2 (33%)	2 (8%)	0 (0%)	0(0%)
Question 6	7 (27%)	4 (67%)	5 (83%)	18 (69%)	2 (33%)	1 (17%)	1 (4%)	0 (0%)	0(0%)
Question 7	3 (12%)	5 (83%)	6 (100%)	21 (81%)	1 (17%)	0 (0%)	2 (8%)	1 (17%)	0(0%)

*Number of responsees ** % of responsees

Table (4.8)
Summary of Responsees to the Perceptual Question for the Route Planning Effectiveness Factor

	Number and Percentage of Responsees		
Question 8	Small	Medium	Large
Very Ineffective	1 (4%)	0 (0%)	0 (0%)
Ineffective	1 (4%)	0 (0%)	1 (17%)
Moderately Ineffective	4 (15%)	0 (0%)	0 (0%)
Effective	11 (42%)	3 (50%)	0 (0%)
Very Effective	5 (19%)	3 (50%)	5 (83%)
N/A	4 (15%)	0 (0%)	0 (0%)

For question four, 16 companies out of the 26 small fleet size companies (62%) are subjecting all journeys to managerial approval. This corresponds well with the answers received for question one which asks if a route/journey management plan is in place as the majority (81%) of the small size companies also replied Yes to this question. In the case of the medium and large companies, 100% of them replied Yes to question one and question four as shown in Table (4.7).

As shown in Table (4.7), disagreement may be seen when replies to question one and question six are compared as only seven small size companies (27%) declared to have clearly defined and mapped routes whereas, as mentioned before, 81% of small companies claim to have route/journey management plan.

Having no clear and defined routes would naturally result in non-identification of potential hazards in the route. For the small fleet size companies this problem is true as can be seen from their answers to question six (69% replied No) and question seven (81% replied No). Whereas, it

would be expected from medium and large companies to define the routes and identify the hazards as the clear majorities of both large and medium companies replied Yes to both question six and question seven as shown in Table (4.7).

A potential hazard in a route can be deduced, to a great extent, from the accident statistics of that particular route. Therefore, the answers to question two and question seven can be related. As mentioned before, twenty one (81%) small fleet size companies do not identify hazards in routes. This corresponds with the clear majority of 96% that do not use accidents statistics of routes. Fortunately this is not the case with medium and large fleet size companies as their answers for question two and question seven show compatibility.

Accident hazards while transporting raw sewage by trucks is increased as the number of journeys per job or the total journeys per day is increased. Therefore, imposing measures to reduce or limit the number of journeys per job and subsequently per day can have a positive effect in reducing this hazard. Question three and question five explore if the sewage trucking companies set a target number of jobs per day, and if measures are taken to reduce the number of journeys in order to complete this targeted number of jobs (e.g., by using bigger capacity trucks to complete a big job and therefore reducing the number of journeys). Replies from small fleet size companies were almost equally split between Yes and No to having a target number of jobs per day as 11 (42%) answered Yes and 15 (58%) answered No. Whereas, five (19%) replied Yes to taking measures to reduce the number of journeys to complete jobs and 19 companies (73%) replied with No to taking such measures. The four medium size companies (67%) who

replied Yes to having a target number of jobs per day also replied Yes to taking measures to reduce the number of journeys. Whereas, in the case of large fleet size companies, all of them (100%) replied Yes to question three, and 67% of them (4 companies) replied Yes to question five.

For the perceptual question which asks about the effectiveness of communications between the drivers and the operation center during journeys, the replies from all sub-groups came compatible with the answers to question one (having a route/journey management plan) as can be seen from Table (4.7) and Table (4.8).

4.3.2 Effectiveness of Route Planning Index (ERPI)

This index measures the effectiveness of the company in implementing route planning management system. This subsection provides concise description of the criteria that may be applied for hazardous materials highway route selection decisions, and illustrates the application of these criteria. The Effectiveness of the Route Planning Index (ERPI) is based on seven sub-indices (ERPI(i); $i=1, 2, 3 \dots, 7$), as shown in Table (4.9).

Table (4.9)

Route Planning Sub-indices

Sub-index(i)	Sub-index description ERPI(i)
1	Availability of route/journey management plan
2	Use of accident statistic in route planning
3	Completing the target number of journeys per day
4	Subjecting all journeys to managerial approval
5	Imposing efforts to reduce the number of journeys per job
6	Clearly defined and mapped routes
7	Identifying potential hazards in the route

The Effectiveness Index of RPF(i) (ERPI(i)) is established from the number of Yes responses over the sample size as shown in the Equation (4.6) below:

$$ERPI(i) = \frac{\text{No.of Yes Respondees of RPF(i)}}{\text{Sample Size}} \quad (4.6)$$

The Overall Effectiveness Index of RPF (OERPI) is established by the following equation:

$$OERPI = \frac{\sum_{i=1}^7 IRPF(i) * ERPI(i)}{\sum_{i=1}^7 IRPF(i)} \quad (4.7)$$

Where IRPF(i) is the importance of RPF(i), it is established based on the experts' questionnaire such that the highest importance value is equal to 7, and the lowest value is 1.

The numbers of Yes responses collected for the sub-factors of the second main factor, i.e. the Route Planning, and their importance ratings are shown in Table (4.10).

For example, calculation of the effectiveness of the first sub-index (Availability of route/journey management plan) is as follows:

$$ERPI(1) = \frac{32}{38} = 0.84$$

Similarly, the effectiveness of other indices are calculated and shown in Table (4.10).

Table (4.10)**Number of Responses and Importance Ratings of the Route Planning Sub-factors**

Sub-factor(i)	Route Planning Sub-factor description	No. of Yes	Effectiveness Sub-index	Import. Rating
1	Availability of route/journey management plan	32	0.84	6
2	Use of accident statistic in route planning	8	0.21	4
3	Completing the target no. of journeys per day	21	0.55	2
4	Subjecting all journeys to managerial approval	27	0.97	4
5	Imposing efforts to reduce the no. of journeys per job	15	0.39	3
6	Clearly defined and mapped routes	16	0.42	5
7	Identifying potential hazards in the route	14	0.37	5
Total No. of Yes Respondents		133		

The calculation of the overall effectiveness of route planning index (OERPI) using Equation (4.7) is as follows:

$$\text{OERPI} = \frac{6*0.84 + 4*0.21 + 2*0.55 + 4*0.71 + 3*0.39 + 5*0.42 + 5*0.37}{6 + 4 + 2 + 4 + 3 + 5 + 5} = 0.516$$

Thus, the overall effectiveness of the route planning index is 51.6%.

4.3.3 Perceptual indices

In addition to the effectiveness of the route planning index, one perceptual index for route planning (RPPI(i); i=1) is defined for the following perceptual indicator:

1- Effective communications' techniques between the trucks and the operations center during the journey.

The determination of the Route Planning Perceptual Index RPPI(1) is performed by using Equation (4.8):

$$RPPI(1) = \frac{\sum_{j=1}^5 w_j * f_{1j}}{5 * \text{Sample size}} \quad (4.8)$$

Where f_{1j} is the frequency of index 1 for rating w_j ($j= 1, 2, \dots, 5$) as established by the experts.

Since the perceptual index of route planning is single, hence its weight is equal to 1.

Finally, the Overall Perceptual Index of Route Planning (ORPPI) is equal to RPPI.

For example, the number of responses collected for the second main factor indicator, which is the Route Planning, is shown in Table (4.11).

Table (4.11)
Number of Responses of the Route Planning Indicator

No.	Route Planning Perceptual Indicator	No. of Respondees					
		Rating Scale (w_j)					NA
		1	2	3	4	5	
1	Effective communications techniques between the trucks and the operations center during the journey	1	2	4	14	13	4

1=Very Ineffective; 2=Ineffective; 3=Moderately Ineffective; 4=Effective; and 5=Very Effective.

The calculation of the perceptual index of the Route Planning Indicator by using Equation (4.8) is as follows:

$$\mathbf{RPPI(1)} = \frac{(1*1 + 2*2 + 4*3 + 14*4 + 13*5)}{5*38} = 0.726.$$

The Overall Route Planning Perceptual Index is:

$$\text{ORPPI} = 0.726 * 1 = 0.726.$$

Thus, the overall route planning perceptual index is 72.6%.

4.4 Analysis of Accidents Management Factor

In analyzing the accident management factor in the sub-sections to follow, an evaluation for both the objective and perceptual questions is carried out followed by determining the overall efficiency of the accident management index and the accident management perceptual index.

4.4.1 Objective and perceptual evaluations

The frequency of answers (Yes , No or Don't know) to each objective question based on the different fleet size sub-groups were listed and given a percentage weight relative to the total number of answers, as shown in Table (4.12). Also Table (4.13) shows the frequencies of ratings to questions six to eight from the three sub-groups.

Table (4.12)
Summary of Respondee to the Objective Questions for the Accidents Management Factor

	Yes Respondee			No Respondee			Don't know Respondee		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Question 1	2* (8%)**	4 (67%)	3 (50%)	13 (50%)	1 (17%)	3 (50%)	11 (42%)	1 (17%)	0 (0%)
Question 2	9 (35%)	3 (50%)	3 (50%)	15 (58%)	2 (33%)	3 (50%)	2 (8%)	1 (17%)	0 (0%)
Question 3	20 (77%)	5 (83%)	6 (100%)	4 (15%)	0 (0%)	0 (0%)	2 (8%)	1 (17%)	0 (0%)
Question 4	9 (35%)	4 (67%)	2 (33%)	15 (58%)	1 (17%)	4 (67%)	2 (8%)	1 (17%)	0 (0%)
Question 5	22 (85%)	6 (100%)	5 (83%)	2 (8%)	0 (0%)	0 (0%)	2 (8%)	1 (17%)	1 (17%)

*Number of respondees ** % of respondees

Table (4.13)

**Summary of Respondees to the Perceptual Questions for the Accidents
Management Factor**

	Number and Percentage of Respondees		
Question 6	Small	Medium	Large
Very Ineffective	0 (0%)	0 (0%)	1 (17%)
Ineffective	0 (0%)	1 (17%)	0 (0%)
Moderately Ineffective	2 (8%)	1 (17%)	0 (0%)
Effective	6 (23%)	0 (0%)	2 (33%)
Very Effective	0 (0%)	4 (67%)	1 (17%)
N/A	18 (69%)	0 (0%)	2 (33%)
Question 7	Small	Medium	Large
Very Ineffective	0 (0%)	0 (0%)	0 (0%)
Ineffective	1 (4%)	1 (17%)	1 (17%)
Moderately Ineffective	4 (15%)	0 (0%)	0 (0%)
Effective	15 (58%)	1 (17%)	2 (33%)
Very Effective	3 (12%)	4 (67%)	3 (50%)
N/A	3 (12%)	0 (0%)	0 (0%)
Question 8	Small	Medium	Large
Very Ineffective	0 (0%)	0 (0%)	1 (17%)
Ineffective	0 (0%)	0 (0%)	0 (0%)
Moderately Ineffective	0 (0%)	1 (17%)	0 (0%)
Effective	5 (19%)	3 (50%)	2 (33%)
Very Effective	20 (77%)	1 (17%)	3 (50%)
N/A	1 (4%)	1 (17%)	0 (0%)

Analyzing the data of Tables (4.12) and (4.13) enables validation of the trueness of the replies or identifying discrepancies in replies. The questions that can be compared in order to work out the efficiency with the accidents management are discussed and analysed below.

For question four, fifteen small sized companies (58%) replied No to having accident spillage incidents records and thirteen (50%) of them replied No to question one “having accident records” as shown in Table (4.12) above. It can be deduced that the replies to both question one and question four are in

line with each other's. In the case of the medium fleet companies, it can be seen obviously that same number of companies replied Yes to both questions. But, for the large fleet companies, there is a discrepancy as three companies (50%) replied Yes to question one, while only two companies (33%) replied Yes to question four. Even though, it cannot be fully concluded that the accidents management is not adhered to since the percentages of the Yes replies are high enough.

For question three, 77% of the small fleet size companies replied Yes to having an accident investigation procedure, while only 35% of these companies replied Yes to question 2 that they having an accident recovery procedure as shown in Table (4.12) above. Meanwhile, 100% of the large fleet sub-group replied Yes to question three of having an accident investigation procedure and 50% of them claimed to have an accident recovery procedure. Looking at these percentages for the replies to question two and question three, small differences are expected between the percentages of the two questions for each sub-group because having an accident investigation procedure is usually associated with presence of an accident recovery procedure to draw up an action plan to be implemented in the event of accident.

Company vehicles inspection procedures are critical in avoidance of accidents and can subsequently aid greatly in the accident management and investigation. By referring back to the inspection sheets once an incident has occurred, the company can deduce the reasons for an accident and if vehicle assignment and maximum loads are adhered to before commencing the journey. In replies to questions six and seven (perceptual questions) which are concerned about ensuring maximum loads and vehicle assignment,

respectively, it can be seen that there is a discrepancy in the case of small fleet size sub-group. More than half (58%) of small companies declared to be “effective” in carrying out vehicle inspection and assignment procedures, but the majority of them (69%) stated that maximum loads are not adhered to. Medium and large fleet sizes companies showed consistency in their replies to question six and question seven as shown in Table (4.13).

4.4.2 Accident Management Efficiency Index (AMEI)

This Index gives an explanation of how effective the company in implementing management system that reduces the number of sewage trucking accidents. The Accident Management Efficiency Index (AMEI) is based on four sub-indices (AMEI(i); i=1, 2, ...,4), as shown in Table (4.14).

Table (4.14)
Accident Management Sub-indices

Sub-index(i)	Sub-index description AMEI(i)
1	Availability of Accident records
2	Availability of accident recovery procedure
3	Availability of accident investigation procedure
4	Availability of accident spillage incident records

The Efficiency Index of AMF(i) (AMEI(i)) is established from the number of Yes responses over the sample size as shown in the Equation (4.9) below:

$$AMEI(i) = \frac{\text{No.of Yes Respondee of AMF(i)}}{\text{Sample Size}} \quad (4.9)$$

The Overall Efficiency Index of AMF (OAMEI) is established by the following equation:

$$OAMEI = \frac{\sum_{i=1}^4 IAMF(i) * AMEI(i)}{\sum_{i=1}^4 IAMF(i)} \quad (4.10)$$

Where IAMF(i) is the importance of AMF(i), it is established based on the experts' questionnaire such that the highest importance value is equal to 4, and the lowest value is 1.

The numbers of Yes responses collected for the sub-factors of the third main factor, i.e. the Accident Management, and their importance ratings are shown in Table (4.15).

For example, calculation of the efficiency of the first sub-index (Availability of Accident records) is as follows:

$$AMEI(1) = \frac{19}{38} = 0.50$$

Similarly, the efficiency of other indices are calculated and shown in Table (4.15).

Table (4.15)
Number of Responses and Importance Ratings of the Accident Management Sub-factors

Sub-factor(i)	Accident Management Sub-factor description	No. of Yes	Efficiency Sub-index	Import. Ratings
1	Availability of Accident records	19	0.50	3
2	Availability of accident recovery procedure	15	0.39	3
3	Availability of accident investigation procedure	31	0.82	2
4	Availability of accident spillage incident records	15	0.39	3
Total No. of Yes Respondents		80		

The calculation of the overall efficiency of accident management index (OAMEI) using Equation (4.10) is as follows:

$$OAMEI = \frac{3*0.50 + 3*0.39 + 2*0.82 + 3*0.39}{3+3+2+3} = 0.500$$

Thus, the overall efficiency of accident management index is 50%.

4.4.3 Perceptual indices

In addition to the accident management efficiency index, three perceptual indices for accident management (AMPI(i); i=1,2,3) are defined for the following three perceptual indicators (an index for each indicator):

- 1- Effective procedures in ensuring maximum loads of the truck
- 2- Effective vehicles inspection and assignment procedures
- 3- Communication procedures with head office in regards with collection and delivery times log.

The determination of the Accident Management Perceptual Index AMPI(i) is performed by using Equation (4.11):

$$AMPI(i) = \frac{\sum_{j=1}^5 w_j * f_{ij}}{5 * Sample\ size} \quad (4.11)$$

Where f_{ij} is the frequency of index i for rating w_j ($j= 1, 2, ..5$) as established by the experts.

The weight of each perceptual indicator is calculated by using Equation (4.12):

$$WAMPI(i) = \frac{AMPI(i)}{\sum_{i=1}^3 AMPI(i)} \quad (4.12)$$

Finally, the Accident Management Overall Perceptual Index (OAMPI) is determined by using Equation (4.13):

$$OAMPI = \sum_{i=1}^3 AMPI(i) * WAMPI(i) \quad (4.13)$$

Where $WAMPI(i)$ is the weight of the accident management perceptual indicator (i) (i= 1,2, 3).

For example, the numbers of responses collected for this third main factor indicators, i.e. Accidents Management, are shown in Table (4.16).

Table (4.16)

Number of Responses of the Accidents Management Indicators

No.	Accidents Management Perceptual Indicator	No. of Responses					
		Rating Scale (w_j)					NA
		1	2	3	4	5	
1	Effective procedures in ensuring max loads of the truck	1	1	3	8	5	20
2	Effective vehicles inspection and designation procedures	0	3	4	18	10	3
3	Communication procedures with head office in regards with collection and delivery times log.	1	0	1	10	24	2

1=Very Ineffective; 2=Ineffective; 3=Moderately Ineffective; 4=Effective; and 5=Very Effective.

The calculation of the perceptual index of the first Accidents Management Indicator by using Equation (4.11) is as follows:

$$AMPI(1) = \frac{(1*1 + 1*2 + 3*3 + 8*4 + 5*5)}{5*38} = 0.363;$$

For the second indicator is:

$$AMPI(2) = \frac{(0*1 + 3*2 + 4*3 + 18*4 + 10*5)}{5*38} = 0.737;$$

And for the third indicator is:

$$\text{AMPI}(3) = \frac{(1*1 + 0*2 + 1*3 + 10*4 + 24*5)}{5*38} = 0.863.$$

The calculation of the weight of the first Accidents Management Perceptual Indicator by using Equation (4.12) is as follows:

$$\text{WAMPI}(1) = \frac{0.363}{0.363 + 0.737 + 0.863} = 0.185;$$

For the second indicator is:

$$\text{WAMPI}(2) = \frac{0.737}{0.363 + 0.737 + 0.863} = 0.375;$$

And for the third indicator is:

$$\text{WAMPI}(3) = \frac{0.863}{0.363 + 0.737 + 0.863} = 0.440.$$

The Overall Accident Management Perceptual Index is obtained by using Equation (4.13):

$$\text{OAMPI} = 0.363 * 0.185 + 0.737 * 0.375 + 0.863 * 0.440 = 0.723.$$

Thus, the overall accident management perceptual index is 72.3%.

4.5 Analysis of Vehicles Reliability Factor

In analyzing the vehicle reliability factor in the sub-sections to follow, an evaluation for the objective questions is carried out followed by determining the overall vehicles reliability index.

4.5.1 Objective evaluations

The frequency of answers (Yes , No or Don't know) to each objective question based on the different fleet size sub groups were listed and given a

percentage weight relative to the total number of answers, and shown in Table (4.17).

Table (4.17)
Summary of Respondee to the Objective Questions for the Vehicles Reliability Factor

	Yes Respondee			No Respondee			Don't know Respondee		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Question 1	25* (96%)**	6 (100%)	6 (100%)	1 (4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Question 2	2 (8%)	4 (67%)	3 (50%)	20 (77%)	2 (33%)	3 (50%)	4 (15%)	0 (0%)	0 (0%)
Question 3	7 (27%)	6 (100%)	5 (83%)	13 (50%)	0 (0%)	1 (17%)	6 (23%)	0 (0%)	0 (0%)
Question 4	4 (15%)	4 (67%)	5 (83%)	20 (77%)	2 (33%)	1 (17%)	2 (8%)	0 (0%)	0 (0%)

*Number of respondees ** % of respondees

Analyzing the data of Table (4.17) enables validation of the trueness of the replies or identifying discrepancies in replies. The questions that can be compared in order to work out the reliability of vehicles are discussed and analyzed below.

For question one, 96% of the Small Fleet Size companies replied Yes to conducting periodical vehicle inspections, while only 15% of these companies replied Yes to question 4 that they having a pre-trip vehicle check list as shown in Table (4.17) above. In the case of the large fleet and medium fleet companies, all (100%) of large companies and medium size companies claimed to conducting periodical vehicle inspections, but in return, 83% of large companies and 67% of medium size companies claimed to have a pre-trip vehicle check list in place. Looking at these percentages for the replies to question one and question four, small differences are expected between the percentages of the two questions for each sub-group because having a pre-trip vehicle check list is usually associated with conducting periodical vehicle inspections.

Question three investigates if companies do place a spill recovery plan in the vehicles for the drivers to follow in case of a sewage spill. The reply to this question is related to the reply to question two which asks if all vehicles contain copies of safety policies and procedures. As can be seen from Table (4.17), seven (27%) of the 26 small size companies replied Yes to question three while 2 of them (8%) replied Yes to question two. Whereas for the medium size companies, all of them replied Yes to question three while 4 of them (67%) replied Yes to question two, and five of the large fleet size

companies replied Yes to question three and 3 of them (50%) replied Yes to question two. Showing minor differences.

4.5.2 Vehicles Reliability Index (VRI)

This Index gives an indication of how effective the company in implementing a management system that ensures the vehicle reliability for use in raw sewage transport. The Vehicles Reliability Index (VRI) is based on four sub-indices (VRI(i); i=1, 2, ..,4), as shown in Table (4.18).

Table (4.18)
Vehicles Sub-indices

Sub-index(i)	Sub-index description VRI(i)
1	Vehicle periodical inspections
2	Availability of safety policy and procedure in vehicle
3	Availability of vehicle spill recovery plan
4	Availability of pre-trip vehicle check list

The Vehicles Reliability sub-index (VRI(i)) is established from the number of Yes responses divided by the sample size as shown in the Equation (4.14) below:

$$VRI(i) = \frac{\text{No.of Yes Respondees of VRF(i)}}{\text{Sample Size}} \quad (4.14)$$

The Overall Vehicle Reliability Index (OVRI) is established by the following equation:

$$OVRI = \frac{\sum_{i=1}^4 IVRF(i) * VRI(i)}{\sum_{i=1}^4 IVRF(i)} \quad (4.15)$$

Where $IVRF(i)$ is the importance of $VRF(i)$, it is established based on the experts' questionnaire such that the highest importance value is equal to 4, and the lowest value is 1.

The numbers of Yes responses collected for the sub-factors of the fourth main factor, i.e. the Vehicles Reliability, and their importance ratings are shown in Table (4.19).

For example, calculation of the reliability of the first sub-index (Vehicle periodical inspections) is as follows:

$$VRI(1) = \frac{37}{38} = 0.97$$

Similarly, the reliability of other indices are calculated and shown in Table (4.19).

Table (4.19)
Number of Responses and Importance Ratings of the Vehicles Sub-factors

Sub-factor(i)	Vehicles Sub-factor description	No. of Yes	Reliability Sub-index	Importance Rating
1	Vehicle periodical inspections	37	0.97	3
2	Availability of safety policy and procedure in vehicle	9	0.24	2
3	Availability of vehicle spill recovery plan	18	0.47	2
4	Availability of pre-trip vehicle check list	13	0.34	3
Total No. of Yes Respondents		77		

The calculation of the overall vehicle reliability index (OVRI) using Equation (4.15) is as follows:

$$\text{OVRI} = \frac{3 \times 0.97 + 2 \times 0.24 + 2 \times 0.47 + 3 \times 0.34}{3 + 2 + 2 + 3} = 0.537$$

Thus, the overall vehicles reliability index is 53.7%.

4.6 Summary of Objective and Perceptual Indices of the Main Factors

The objective indices and perceptual indices for each of the main factors of safety assessment model of raw sewage transportation by trucks are summarized in the Table (4.20) below.

Table (4.20)
Summary of Objective Indices and Perceptual Indices

No.	Factor	Objective indices		Perceptual indices	
		Index	Value	Index	Value
1	Safety Policy Compliance	OCSPI	0.539	OSPPI	0.609
2	Route Planning Effectiveness	OERPI	0.516	ORPPI	0.726
3	Accidents Management	OAMEI	0.500	OAMPI	0.723
4	Vehicles Reliability	OVRI	0.532	-	-

For all the factors, the objective indices has fallen around the 0.5 value which indicates that in an objective sense all the companies are moderately conforming to the subject of the factor. Whereas, in a perceptual sense, the companies tend to be more conforming to the subject of the factors as indices show higher values than the objective indices values. Route planning

effectiveness gained 0.726 which is the highest perceptual index followed by the accident management factor.

The above indices are developed through analyzing the main factors and the magnitudes of conformity by the trucking companies to these factors are calculated. A safety index which evaluates the level of safety performance by the trucking companies has emerged from this approach. Therefore this approach can be used as a safety assessment model for transportation of raw sewage by trucks.

4.7 Analysis of Operational and Maintenance Costs

Given the competitive nature of the sewage trucking industry in the Kingdom and the extreme sensitivity associated with corporate financials and expenditures, the operational and maintenance cost information was collected through the questionnaire in order to be analysed against the safety assessment.

4.7.1 Operational Costs

The operational cost is mainly related to truck driver's salaries and fuel consumption relative to fleet size which is defined in Section 4.1. In analyzing the data collected from the questionnaires' replies the following Table (4.21) is drawn up.

Table (4.21)

Summary of Respondees to the Drivers Salaries

	Small	Medium	Large
Low (1-3 BD per hour)	21* (81%)**	3 (50%)	1(17%)
Average (4-6 BD per hour)	3 (12%)	2 (33%)	4 (67%)
High (>7 BD per hour)	0 (0%)	0 (0%)	0 (0%)
No reply	2 (8%)	1 (17%)	1 (17%)

*Number of respondees ** % of respondees

As it can be seen in Table (4.21), 21 (81%) of the small fleet size companies declared to have low wage drivers whereas the majority (67%) of the large fleet size companies have average waged truck drivers. In the case of the medium fleet size companies, 3 companies declared to have low salaries and 2 companies declared average. None of the sample companies pay high wages to drivers no matter what the years of experience are.

Fuel costs can be concluded to be directly related to fleet sizes i.e. large fleet size companies would shoulder more fuel costs than small fleet size companies. But also, small fleet size companies can pay more fuel costs if they have to make more journeys per trucking job since they don't have the capacity in order to complete daily job targets.

4.7.2 Maintenance Costs

The maintenance cost for the sewage trucking companies is mainly related to the periodical maintenance of vehicles, and if this periodical maintenance is done in house or by service provider. In analyzing the data collected from the questionnaires' replies the following Tables (4.22), (4.23) and (4.24) are drawn up.

Table (4.22)

Summary of Respondees to the Average Periodical Maintenance

Fleet Size	Small	Medium	Large
Average periodical Maintenance	6 month	1 month	3 month

Table (4.23)

Summary of Respondees to the Fleet Model

Fleet Model	Small	Medium	Large
Old (more than 15 years)	0	0	2
Recent (5 years and less than 15 year)	24	4	6
New (less than 5 years)	3	2	1

The average periodical maintenance is compared across the sub-groups in Table (4.22) above. Medium size companies tend to carry out the most frequent maintenance on vehicles, whereas the small fleet size companies carry out the least frequent. As for the fleet model which relates directly to maintenance costs, it can be seen from Table (4.23) above that the great majority of companies across all fleet sizes declared to have a recent model. In the case of large fleet companies, more maintenance is expected as two of them do have old models (more than 15 year old) mixed in with their recent models fleet. It worth to mention that some companies have more than one vehicle model.

Carrying out the periodical maintenance by the vehicle's manufacturer or agency can be significantly higher than carrying the maintenance in-house or at local car garages. It can be seen from Table (4.24) below, the small size companies have a tendency to not carry out the maintenance on vehicles by

manufacturer. Most large and medium fleet size companies do seek the service provider to carry out periodical maintenance on vehicles. The majority of companies across all sub-groups declared to hold spare parts and carry out simple repairs in house, therefore saving in maintenance costs to some extent.

Table (4.24)
Summary of Respondee to the Vehicle Servicing

	Yes Respondee			No Respondee		
	Small	Medium	Large	Small	Medium	Large
Is periodical maintenance done by service provider?	7* (27%)**	5 (83%)	4 (67%)	19 (73%)	1 (17%)	2 (33%)
Is repair maintenance and spares done in-house?	16 (62%)	4 (67%)	6 (100%)	10 (38%)	2 (33%)	0 (0%)

*Number of respondee ** % of respondee

Table (4.25) below gives a quick glance on the drivers age and years of experience across the three sub-groups, these are factors which could contribute towards vehicles maintenance costs. All sub-groups declared that their truck driver's practices are well by indicating an average of 7 years, which may imply reduced maintenance costs. Large fleet companies have more experienced drivers compared to medium and small fleet size companies; this could mean that large fleet companies face less cost to maintenance of vehicles.

Table (4.25)

Summary of Respondee's to the Drivers related Questions

	Small	Medium	Large
Average staff's driving practices	7	7	7
Average driver's years of experience	9	7	11
Average driver's age (years)	31	28	41
Average driver's working hours per day	11	11	11

Chapter Five

Safety Mapping

5.1 Introduction

5.2 Safety Policy Compliance Map

5.3 Route Planning Effectiveness Map

5.4 Accident Management Map

5.5 Vehicles Reliability Map

Chapter Five

Safety Mapping

5.1 Introduction

A safety map is the simplest form of a graphical representation in which the evaluation of the sub-factors of the main factors of the safety assessment model of raw sewage transportation by trucks form the x axes, while their importance form the y axes. The way to prioritize the sub-factors is by designating an importance level for each area of the graph such as Very High (VH), High (H), Medium (M), Low (L) and Very Low (VL), as shown in Figure (5.1). Where the higher the combined field and importance ratings, is the higher the overall level of safety concern.

		Evaluation of Sub-factors				
		VL	L	M	H	VH
Importance of Sub-factor	VH					
	H					
	M					
	L					
	VL					

Figure (5.1)

Example of Safety Map

Where the limits range for each region is as shown below:

VL	$\leq 20\%$
L	20% - 40%
M	40% - 60%
H	60% - 80%
VH	80% - 100%

The red region of the map is where safety is considered to be highly compromised, the yellow region is where safety is moderately compromised, and the green region indicates safety requirements are achieved.

The safety maps for the main four factors are presented in the following sections.

5.2 Safety Policy Compliance Map

The compliance percentages of safety policy sub-factors are established by using Equation (4.1), and their importance ratings' percentages are established based on the experts' rating for each sub-factor divided by the number of sub-factors as shown in Table (5.1).

Table (5.1)
Percentage of Compliance and Importance Ratings of the Safety Policy Sub-factors

Sub-factor (i)	Safety Policy Compliance Sub-factor	% ISPF(i)	%CSPI(i)
1	Availability of predefined transport safety program	83%	74%
2	Holding periodic safety meetings	50%	55%
3	Established safety committee	67%	42%
4	Conducting risk assessment analysis prior to new trucking orders	67%	37%
5	Conducting periodic health & safety training for drivers	67%	61%
6	Carrying periodical health check for drivers	33%	47%

Thus, the map for safety policy compliance factor by using Table (5.1) is as follows:

		Compliance				
		VL	L	M	H	VH
Importance	VH				1	
	H		4	3	5	
	M			2		
	L			6		
	VL					

Figure (5.2)

Safety Policy Compliance Map

As it is shown in Figure (5.2), the fourth sub-factor (Conducting risk assessment analysis prior to attending new trucking orders) has high importance but the compliance is low, therefore it falls in the red region which means a critical review is needed. While the first, second, third and fifth sub-factors fall in the medium region, which indicates more elaboration is required.

Thus, the hazard associated with safety policy compliance factor is not “conducting risk assessment analysis prior to attending new trucking orders”. Not carrying out such assessment prior to attending raw sewage trucking journeys can prevent from recognizing and controlling problems arising during these journeys. The more informed and aware the drivers of the risks, the lower the number of incidents will be. Also conducting risk assessment analysis can reduce the cost by being proactive and work towards preventing incidents rather than being reactive post the incidents which usually costs more.

5.3 Route Planning Effectiveness Map

The effectiveness percentages of route planning sub-factors are established by using Equation (4.6), and their importance ratings’ percentages are

established based on the experts' rating for each sub-factor divided by the number of sub-factors as shown in Table (5.2).

Table (5.2)

Percentage of Effectiveness and Importance Ratings of the Route Planning Sub-factors

Sub-factor (i)	Route Planning Effectiveness Sub-factor	% IRPF(i)	%ERPI(i)
1	Availability of route/journey management plan	86%	84%
2	Use of accident statistic in route planning	57%	21%
3	Completing the target number of journeys per day	29%	55%
4	Subjecting all journeys to managerial approval	57%	97%
5	Imposing efforts to reduce the number of journeys per job	43%	39%
6	Clearly defined and mapped routes	71%	42%
7	Identifying potential hazards in the route	71%	37%

Thus, the map for route planning effectiveness factor by using Table (5.2) is as follows:

		Effectiveness				
		VL	L	M	H	VH
Importance	VH					1
	H		7	6		
	M		2&5			4
	L			3		
	VL					

Figure (5.3)

Route Planning Effectiveness Map

As it is shown in Figure (5.3), the seventh sub-factor (Identifying potential hazards in the route) has fallen in the red region as its effectiveness is low and its importance is considered to be high. Therefore, the result of this sub-

factor needs reviewing. While the second, fifth and sixth sub-factors need more elaboration.

Thus, the hazard associated with “route planning effectiveness factor” is that the potential hazards in the delivery route will not be identified beforehand. By planning a route and identifying hazards in delivery routes, companies and their drivers will be able to predict hazardous aspects of road design, approach to customer’s premises etc. Alternative, safer routes and times may be considered and thus potentially avoid incidents.

5.4 Accident Management Map

The efficiency percentages of accident management sub-factors are established by using Equation (4.9), and their importance ratings’ percentages are established based on the experts’ rating for each sub-factor divided by the number of sub-factors as shown in Table (5.3).

Table (5.3)

Percentage of Efficiency and Importance Ratings of the Accident Management Sub-factors

Sub-factor (i)	Accident Management Efficiency Sub-factor	% IAMF(i)	%EAMI(i)
1	Availability of Accident records	75%	50%
2	Availability of accident recovery procedure	75%	39%
3	Availably of accident investigation procedure	50%	82%
4	Availability of accident spillage incident records	75%	39%

Thus, the map for accident management factor by using Table (5.3) is as follows:

		Efficiency				
		VL	L	M	H	VH
Importance	VH					
	H		2&4	1		
	M					3
	L					
	VL					

Figure (5.4)

Accident Management Efficiency Map

As it is shown in Figure (5.4), the results for two high importance sub-factors, i.e. Availability of accident recovery procedure and accident spillage incident records (second and fourth) require critical review as they came with low efficiency while the placement of the first sub-factor require further elaboration.

Thus, the hazards associated with accident management efficiency are non-availability of accident recovery procedure and accident spillage incident records. After an incident involving raw sewage, a recovery plan which the drivers are trained on and familiar with is essential in order to minimize the impact of the spillage of the raw sewage as much as possible and therefore reducing the impact on the immediate vicinity. Spillage records can be used to feed into drawing up the recovery plans as lessons learned from previous incidents.

5.5 Vehicles Reliability Map

The reliability percentages of vehicles sub-factors are established by using Equation (4.14), and their importance ratings' percentages are established based on the experts' rating for each sub-factor divided by the number of sub-factors as shown in Table (5.4).

Table (5.4)

Percentage of Reliability and Importance Ratings of the Vehicles Sub-factors

Sub-factor (i)	Vehicles Reliability Sub-factor	%IVR	%VRI(i)
1	Vehicle periodical inspections	75%	97%
2	Availability of safety policy and procedure in vehicle	50%	24%
3	Availability of vehicle spill recovery plan	50%	47%
4	Availability of pre-trip vehicle check list	75%	34%

Thus, the map for vehicles reliability factor by using Table (5.4) is as follows:

		Reliability				
		VL	L	M	H	VH
Importance	VH					
	H		4			1
	M		2	3		
	L					
	VL					

Figure (5.5)

Vehicles Reliability Map

As it is shown in Figure (5.5), further elaboration is needed for the second and third sub-factors. While, the highly important sub-factor four (Availability of pre-trip vehicle check list) should be critically reviewed, because it has low reliability.

Therefore, the hazard associated with vehicles reliability factor is non-availability of pre-trip vehicle check list. Safety is the most important and obvious reason to inspect a vehicle before launching a trip. A vehicle defect found during an inspection could save incidents during a trip.

5.6 Summary of Safety Mapping of the Main Factors

The potential hazards associated with each of the main factors of safety assessment model of raw sewage transportation by trucks are pointed out from safety mapping and summarized in the Table (5.5) below.

Table (5.5)
Summary of the Hazards Associated with Transportation of Raw Sewage by Trucks

Factor	Factor Description	Hazards
1	Safety Policy Compliance	Not conducting risk assessment analysis prior to attending new trucking orders.
2	Route Planning Effectiveness	Not identifying the potential hazards in the delivery route.
3	Accident Management Efficiency	Non-availability of accident recovery procedure and accident spillage incident records.
4	Vehicles Reliability	Non-availability of pre-trip vehicle check list

For all the factors, the hazards have fallen in the high importance and low effectiveness region. The accident management efficiency factor is the only factor which has more than one hazard which are non-availability of accident recovery procedure; and non-availability of accident spillage incident records.

Safety mapping's primary purpose is to inform the trucking companies of the hazards associated with transport of raw sewage by trucks. Then, the responsibility of trucking companies is to carry out safety mapping exercises to investigate the hazards individually, rank and prioritize them. Because of

the nature of safety performance level of the trucking companies, the map will be revised on a regular basis.

Chapter Six

Conclusions and Recommendations

6.1 Conclusion

6.2 Recommendations

6.3 Future Work

Chapter Six

Conclusions and Recommendations

6.1 Conclusion

The major focus of this research effort was to evaluate the safety level of practices in the ever expanding industry of raw sewage transport by trucks in the Kingdom of Bahrain and the following conclusions were drawn:

- 1- As the population in the Kingdom of Bahrain grows and even though different methods of sewage transport are available in the kingdom, trucking still plays a major role in sewage transportation.
- 2- The safety mapping is a new concept in safety analysis. It would help in visualizing and identifying sub-factors where more elaboration is needed. Also, this safety mapping has aided in drawing up the hazards associated with the main factors of the safety assessment model where a critical review is needed by the trucking companies.
- 3- Trucking of raw sewage in a safe manner is compromised to a certain extent in smaller fleet size companies than those with larger fleets. The analysis of the cross-tabulation between the questions related to having predefined safety program, establishing a safety committee and holding periodical safety meetings can be conceived to reach to this conclusion. Sixty two percent of the small fleet size companies have a pre-defined transport safety policy, while only 27% of these companies have an established safety committee. Meanwhile, 100%

of the large fleet have a transport safety policy and 83% of them do have a safety committee establishment to oversee this policy. Small differences are expected between the percentages because having a pre-defined safety policy and having periodical safety meetings are strongly associated with presence of a safety committee to draw up and/or follow such policies but analysis of the percentages for the replies to the related questions have showed otherwise. The cross tabulation has also shown that conducting risk assessment analysis prior to trucking journeys is not a strength of the majority of small size companies as (65%) replied with a No and this conforms well with the fact that seven (27%) small companies claimed to be “ineffective” in taking drivers suggestions in route planning and seven other small companies replied that taking drivers suggestions is “Not Applicable”. This situation is not deduced from larger fleet size companies in the analysis.

- 4- Due to a perceived cost factor, the trucking companies focus their efforts on meeting the job completion target per day and overlook the safety requirements. Fifty five percent of the companies (21 out of 38) have a job completion target per day and the majority of sample companies (58%) do not account for the number of journeys made to complete a sewage trucking job, while 39% (14 out of 38) do put the effort to reduce the number of journeys and therefore reducing the possible risk imposed on the environment. Maximum tank load capacity could have an impact on company's costs in terms of affecting the number of journeys made per trucking job. Sixty six percent of sample companies declared that they do not have maximum tank load policy also the large majority of companies (20 out of 38) of

total respondents declared that having procedures to keep the maximum loads in-check were not applicable. Therefore it can be concluded that the maximum load is not adhered to during journeys.

- 5- A safety assessment model has been suggested in order to evaluate the level of safety performance by the trucking companies. Despite the above mentioned points, the trucking companies were found to be in border line conformity with the main factors when the objective indices were calculated as part of the safety assessment model. The objective indices have fallen around the 0.5 value for all the factors which indicates that in an objective sense all the companies are moderately conforming to the subject of the factor. Whereas in a perceptual sense the compliance is well above average. The companies tend to be more conforming to the subject of the factors as indices show higher values than the objective indices values. Route planning effectiveness gained 0.726 which is the highest perceptual index followed by the accident management factor which gained 0.723. The development and use of indices in analyzing both objective and perceptual questionnaire questions is a new approach.

Therefore, the defined objectives of this study have been achieved.

6.2 Recommendations

From the findings concluded above, and the recommendations can be drawn up as follows;

- The sewage trucking industry is to be regulated by the authorities to a greater extent in accordance with international standards and industry

- best practices and be included under the hazmat transportation umbrella in the Kingdom of Bahrain. This will lead to improving the safety of sewage transport by trucks.
- Better distribution of the trucking companies around the Kingdom should be made in order to reduce the risk caused by longer journeys and to facilitate better and easier route planning.
 - The model developed can be used as a base to draw up a comprehensive safety compliance check list for raw sewage trucking to be used by the authorities and the trucking companies.

6.3 Future Work

This study can be followed up by relative studies and research in order to cover wider areas of the industry as follows;

- Risk assessment, management and mitigation options of raw sewage transportation by trucks. A theoretical approach to take corrective and preventive measures to reduce the risks of truck accidents
- Cost analysis or economic assessment of raw sewage transport by truck against conventional sewage transport systems.
- Case study on scenarios of sewage truck accidents that occur along the delivery route to the treatment plant. Application of plume modeling in sewage spillage incidents.
- SWOT and environmental evaluations of raw sewage transportation by trucks.

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Appendices

Appendix 1

First Questionnaire with Sample of Replies

No.	Transportation Company Name	No. of Tanker	Tanker Plate No.	Capacity (Gal)
1	Almoayyed	2	144	4500
			18995	4500
2	Angels	3	1002	4500
			11988	4500
			18646	4500
3	Al waha electrical	2	1060	4500
			11933	4500
4	Mayoof	16	1157	4500
			1158	4500
			1159	4500
			1222	4500
			1371	4500
			1375	4500
			12871	4500
			12925	9000
			14744	9000
			15551	4500
			15561	4500
			16337	4500
			16537	9000
			16841	4500
			17045	4500
			17493	4500
5	Speed star service	4	1210	4500
			10810	4500
			77645	4500
			79331	4500
6	Sphinx	11	1219	4500
			11990	4500
			14246	4500
			16223	9000
			16484	9000
			16545	4500
			16623	4500
			16642	4500
			16902	4500
			16892	4500
			16692	4500
7	zohal	3	1327	4500
			10961	4500
			10971	4500
8	AAA Homes	2	1339	4500
			1539	4500

No.	Transportation Company Name	No. of Tanker	Tanker Plate No.	Capacity (Gal)
9	Ahmed mansoor	10	1353	4500
			11353	4500
			18281	4500
			18548	4500
			18603	4500
			19253	4500
			17107	4500
			15548	4500
			16202	4500
			16456	4500
10	Nidukki	26	1369	4500
			10922	4500
			10927	4500
			10966	4500
			11703	4500
			12544	4500
			12549	4500
			14358	4500
			15791	9000
			16591	4500
			16596	9000
			16696	9000
			17412	4500
			17474	4500
			17477	4500
			17523	4500
			18160	4500
			19224	4500
			11317	4500
			11312	4500
			16789	4500
			11251	4500
			19225	4500
			19523	4500
			19809	4500
			19924	4500
11	Avira	2	1611	4500
			1411	4500
12	Al Safeena	1	1450	4500
13	al Kooheji	3	1490	4500
			11994	4500
			87463	4500

No.	Transportation Company Name	No. of Tanker	Tanker Plate No.	Capacity (Gal)
14	Green mack	10	1523	4500
			1573	4500
			10910	4500
			11040	4500
			11498	4500
			13987	4500
			14178	4500
			12084	4500
			15753	4500
			81654	4500
15	Al hassnain exc.	1	1542	4500
16	GCMS	26	1546	4500
			1550	4500
			1560	4500
			1580	4500
			1590	4500
			14321	4500
			15444	4500
			15513	4500
			16321	4500
			16449	4500
			16786	4500
			18248	4500
			18249	4500
			18444	4500
			19961	4500
			1551	4500
			13309	4500
			11589	4500
			30013	4500
			16499	4500
			11257	4500
			12498	4500
			18266	4500
			15440	4500
			16444	9000
			18246	9000
17	Hafeera con	4	1611	4500
			16801	4500
			12059	4500
			12389	4500
18	Desert eagles	4	1622	4500
			14509	4500
			16229	4500
			17618	4500
19	CCC	7	1664	4500
			1665	4500
			10478	4500
			10935	4500
			11570	4500
			12527	4500
			12772	4500
20	Tariq mohammed	2	16478	4500
			1691	4500
			11995	4500

No.	Transportation Company Name	No. of Tanker	Tanker Plate No.	Capacity (Gal)
21	Al Khalifa	2	1760	4500
			16514	4500
22	spectrum	15	1803	4500
			4631	5000
			8272	9000
			10192	4500
			10324	4500
			18122	9000
			19474	4500
			19674	4500
			19694	4500
			39052	9000
			43265	4500
			43918	9000
			19174	4500
			5833	4500
			39082	4500
23	MCSC	5	1889	4500
			1899	4500
			16109	4500
			16473	4500
			17744	4500
24	Al Deera	3	5833	4500
			15833	4500
			12240	4500

No.	Transportation Company Name	No. of Tanker	Tanker Plate No.	Capacity (Gal)
25	Nasser	26	8437	4500
			8670	4500
			8923	4500
			45020	4500
			44620	9000
			44891	9000
			43258	9000
			8258	4500
			8791	4500
			9621	4500
			9845	4500
			17254	4500
			12894	4500
			14768	4500
			1574	4500
			45876	4500
			40326	4500
			40891	4500
			47069	4500
			45028	4500
			46982	4500
			47574	4500
			11786	4500
			11258	4500
			8473	4500
			47064	4500
26	Al banna	1	10028	4500
27	Armcon	2	10328	4500
			11352	4500
28	Al Tawfeek	27	11025	4500
			11285	4500
			12451	4500
			12891	4500
			13964	4500
			14133	4500
			15587	4500
			15871	4500
			16178	9000
			16794	9000
			18941	4500
			19935	9000
			18476	4500
			16805	4500
			10478	4500
			10568	4500
			10489	4500
			10234	4500
			13154	4500
			1316	4500
			10190	4500
			14348	4500
			14491	4500
			15820	9000
			17451	4500
			18778	4500
			19031	4500

No.	Transportation Company Name	No. of Tanker	Tanker Plate No.	Capacity (Gal)
29	GCCC	8	11097	4500
			12938	4500
			18279	4500
			18766	4500
			18767	4500
			18776	4500
			18983	4500
			19233	4500
30	Inveca service	3	10487	4500
			11014	4500
			11010	4500
31	a.karim al johromi	2	10566	4500
			44465	4500
32	Ascon	33	10620	4500
			11957	4500
			12843	4500
			12873	4500
			13018	4500
			14403	4500
			15433	4500
			15525	4500
			15695	4500
			15750	4500
			16261	4500
			16875	4500
			16895	4500
			17506	4500
			18018	4500
			18273	4500
			18388	4500
			18608	4500
			18628	4500
			18664	4500
			18675	4500
			18695	4500
			18723	4500
			18728	4500
			18957	4500
			18975	9000
			19048	9000
			19058	4500
			19081	4500
			19089	4500
			19403	4500
			19642	4500
			19689	4500
33	Alloys Jalal	4	13151	4500
			17403	4500
			17443	4500
			17463	4500
34	Red mack	5	11783	4500
			16802	4500
			1507	4500
			16344	4500
			12522	4500

No.	Transportation Company Name	No. of Tanker	Tanker Plate No.	Capacity (Gal)
35	Al fajer al zaher	1	12498	4500
36	Jasco	12	14250	4500
			14540	4500
			17086	4500
			18335	4500
			11456	4500
			10955	4500
			13383	4500
			13563	4500
			18562	4500
			19904	4500
37	ali makki	2	19964	4500
			19966	4500
38	Technical Construction Company	4	14768	4500
			15647	4500
			13697	4500
			13897	4500
39	Al manaratain	4	13690	4500
			14023	4500
			15500	4500
			16361	4500
40	GPZ	5	16861	4500
			18500	4500
			16827	4500
			17536	4500
			18449	4500
41	Infinity	2	16824	4500
			18827	4500
42	ABDUL HADI	2	17018	4500
			18984	4500
43	Mettalco skip service	3	17224	4500
			17560	4500
			17622	4500
44	Al Door	2	18355	4500
			10372	4500
45	Al Ahlia	2	18153	4500
			18711	4500
46	Antakia	2	19171	4500
			19925	4500
47	jabal sand	2	40385	4500
			47215	4500
48	Down Town	3	46411	4500
			84622	4500
			12980	4500
			17591	4500
			14766	4500

No.	Transportation Company Name	No. of Tanker	Tanker Plate No.	Capacity (Gal)
49	Al Faisal Loistics	26	11090	4500
			11605	4500
			16262	4500
			16723	4500
			16756	4500
			13465	4500
			13256	4500
			13790	4500
			10372	4500
			107622	4500
			107688	4500
			10655	4500
			13618	4500
			7843	4500
			11094	4500
			11190	4500
			11210	4500
			11245	4500
			11089	4500
			13655	4500
			7853	4500
			7912	4500
			8716	4500
			13699	4500
			11066	4500
			7820	4500
50	Sama	1	16055	4000
Total No.		348		



Questionnaire for studying the risk assessment and management of transportation of raw sewage by trucks

This survey is part of my MSc thesis entitled “**Risk assessment and management of transportation of raw sewage by truck**” to implement/obtain safe management of road transport of sewage in order to reduce the level of accidental risks.

The questions in this survey have been designed to be quick and easy to answer. Completing the survey will help to investigate and study the possibility of accidents and spillages that may occur during transport raw sewage by trucks. This shall present a framework for risk assessment, management and mitigation options.

Please answer each survey question based on your best estimate, drawing upon your professional knowledge and experience. Your response is important to us. If I can assist you in any way, or if you have any questions or comments, please do not hesitate to send an e-mail to fatooma89@hotmail.com or call 33300776.

The information you provide will be held in the strictest confidence. I will not publish, release, or disclose any information identifiable with, company or respondents.

As part of my research I wish to do a small follow up interview, which could be carried out over the telephone or in person. I would be very grateful if you could place your name and a contact email or telephone number.

Thank you very much for your participation

Fatima Hameed Qamber
MSc in Engineering Management Program

Supervisor
Prof. Dr. Elamin M.Elkanzi

Co-Supervisor
Prof. Dr. Saad Suliman

Questionnaire No. ____

Date:

Section 1: General information

Company name:

Nome of respondent:

Job Title:

Qualification: ☐ Diploma ☐ BSc ☐ MSc ☐ Other (specify)

Telephone (mobile is preferred):

E-mail:

State the number of years your company has been established as Sewage Collection and Disposal Service Company:

Section 2: Company Safety Policy

For the following questions, please tick the appropriate box [Yes], [No]

1- Does the company have a pre-defined transport safety program?

Yes [☐]

No [☐]

2- Are periodic safety meetings held?

Yes [☐]

No [☐]

Please indicate how often meetings are held

Daily [☐] Weekly [☐] Monthly [☐]

3- Is a safety committee established?

Yes [☐]

No [☐]

4- Do you conduct risk assessment analysis prior to attending new trucking orders?

Yes [☐]

No []

5- Do all truck (drivers) get periodical health and safety training?

Yes []

No []

6- Do all truck (drivers) get periodical health check?

Yes []

No []

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1 = Very ineffective; 2 = Ineffective; 3 = Moderately Ineffective; 4 = effective; 5 = very Effective

7- How effective is the management in considering the suggestions of drivers in route planning?

Rate 1 [] 2 [] 3 [] 4 [] 5 []

N/A []

8- How effective is the management in considering the suggestions of drivers in route safety improvements?

Rate 1 [] 2 [] 3 [] 4 [] 5 []

N/A []

9- How proactive your company in applying national health and safety procedures ?

Rate 1 [] 2 [] 3 [] 4 [] 5 []

N/A []

Section 2: Journey/Route Planning

For the following questions, please tick the appropriate box [Yes], [No]

1- Does the company have a route/journey management plan?

Yes []

No []

2- Is the route of travel decided according to traffic department accident statistics?

Yes []

No []

3- Does the company have a set job completion target per day?

Yes []

No []

If "Yes", How many?

4- Are all journeys subject to management approval?

Yes []

No []

Specify

5- Are efforts being made to reduce the number of journey to complete jobs?

Yes []

No []

If "No", please state why

6- Is the route clearly defined and mapped?

Yes []

No []

7- Are potential hazards in the route identified?

Yes []

No []

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1= Very ineffective; 2= Ineffective; 3= Moderately Ineffective; 4= effective; 5= very Effective

8- How effective is your communications techniques between the trucks and the operations center during the journey?

Rate 1 [] 2 [] 3 [] 4 [] 5 []

N/A []

Section 3: Accidents

For the following questions, please tick the appropriate box [Yes], [No]

- ***By "Accident" we mean collision of the truck where spillage of the load carried by the truck occurs -***

1- Does the company have written accident records?

Yes [☐]

No [☐]

2- What is the average number of accidents for the last:

2 years [.....]

4 years [.....]

6 years [.....]

3- Does the company have written accident recovery procedures?

Yes [☐]

No [☐]

4- Are accident investigation procedures in place?

Yes [☐]

No [☐]

5- Does the company have records of spillage incidents?

Yes [☐]

No [☐]

6- Does the company believe that spillage accidents have a direct impact on the environment?

Yes [☐]

No [☐]

Please explain briefly

.....

.....

.....

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1= Very ineffective; 2= Ineffective; 3= Moderately Ineffective;
4= effective; 5= very Effective

- 7- How effective are the company's procedures in ensuring that max loads of the truck are not surpassed?

Rate 1 [] 2 [] 3 [] 4 [] 5 []

N/A []

- 8- How effective is the company's vehicles inspection and designation procedures?

Rate 1 [] 2 [] 3 [] 4 [] 5 []

N/A []

- 9- Are Collection and delivery times logged and communicated with head office?

Rate 1 [] 2 [] 3 [] 4 [] 5 []

N/A []

Section 4: Vehicles

For the following questions, please tick the appropriate box [Yes], [No]

- 1- Are all vehicles inspected periodically?

Yes []

No []

Please indicate how often vehicles are checked

Daily [] Weekly [] Monthly []

2- Do all vehicles contain a copy of the safety policies and procedures?

Yes []

No []

3- Does the company have a vehicle spill recovery plan?

Yes []

No []

4- Do you have a pre-trip vehicles check list?

Yes []

No []

Section 5: Operational Costs

For the following questions, please tick the appropriate box:

1- How does the company charge its clients?

Per Job []

Per Load []

Per Distance []

Per Hour []

How much is the average charge?

2- How large do you consider your fleet size?

Small (1- 10 Trucks) []

Medium (10-25 Trucks) []

Large (> 25 Trucks) []

3- How old do you consider your fleet model?

Old (More than 15 years) []

Recent (5 years and less than 15 years) []

New (less than 5 years) []

4- How do you consider your drivers salaries?

Low (1 – 3 BD per hour) []

Average (4 – 6 BD/hour) []

High (>7 BD/hour) []

5- Please state the average for the following:

Driver's years of experience:

Drivers Age :

Drivers Working hours per day:

6- Does the company have a maximum tank load policy for jobs?

Yes []

No []

If "Yes", how much is the maximum load

Section 6: Maintenance Costs

1- How do you consider you staff's driving practices, please rate from 1 to 10,

Rate []

N/A []

2- How often is total maintenance carried out on trucks?

After certain km covered: State Km [.....]

After certain time elapsed: State Time [.....]

3- Is periodical maintenance done by service provider?

Yes []

No []

4- Is repair maintenance and spares done in-house?

Yes []

No []

Section 7: Regulations

The following table summerises the related regulations from the *“PUBLIC COMMISSION FOR THE PROTECTION OF MARINE RESOURCES, ENVIRONMENT & WILDLIFERESOLUTION NO.(3) OF THE YEAR 2006 WITH RESPECT TO THE MANAGEMENT OF HAZARDOUS MATERIALS”*

Place a tick in the “Company’s Awareness” column if you believe your company is aware of the regulation listed:

Regulation Section	Discription	Company’s Awareness
CH.4 - Article (14)	No natural or corporate person shall carry on the business of transporting hazardous waste without a license in this respect to be issued by the Concerned Directorate.	
Ch.4 - Article (17)	1. No hazardous waste shall be transported without being accompanied by a fully completed transportation form from the Generator	
	2. No chemical waste shall be transported without being accompanied by a material safety data sheet, subject to complying with the chemical safety requirements laid down by the Concerned Directorate.	
	3. No hazardous waste shall be transported unless they are packed in the appropriate manner	
	4. Hazardous waste shall not be stored with the carrier.	
	5. No hazardous waste shall be transported to a treatment unit or a disposal site that is not licensed by the Concerned Directorate	
	6. Warning signs determined by the Concerned Directorate shall be displayed on the transport vehicle.	
	7. Waste generated by the spillage of hazardous waste in the course of transportation shall be removed and disposed of in the manner to be decided by the Concerned Directorate.	
	8. Hazardous waste being transported shall be re-packed in case drums or tanks are damaged in the	

	course of transportation.	
	9. Hazardous waste shall not be transported during a peak period.	
	10. Hazardous waste shall be returned to the waste generator if such waste is not accepted by the treatment unit, and Paragraph 4 of this Article shall be complied with.	

THANK YOU

END OF QUESTIONNAIRE



Questionnaire for studying the risk assessment and management of transportation of raw sewage by trucks

This survey is part of my MSc thesis entitled “**Risk assessment and management of transportation of raw sewage by truck**” to implement/obtain safe management of road transport of sewage in order to reduce the level of accidental risks.

The questions in this survey have been designed to be quick and easy to answer. Completing the survey will help to investigate and study the possibility of accidents and spillages that may occur during transport raw sewage by trucks. This shall present a framework for risk assessment, management and mitigation options.

Please answer each survey question based on your best estimate, drawing upon your professional knowledge and experience. Your response is important to us. If I can assist you in any way, or if you have any questions or comments, please do not hesitate to send an e-mail to fatoooma89@hotmail.com or call 33300776.

The information you provide will be held in the strictest confidence. I will not publish, release, or disclose any information identifiable with, company or respondents.

As part of my research I wish to do a small follow up interview, which could be carried out over the telephone or in person. I would be very grateful if you could place your name and a contact email or telephone number.

Thank you very much for your participation

Fatima Hameed Qamber
MSc in Engineering Management Program

Supervisor
Prof. Dr. Elamin M.Elkanzi

Co-Supervisor
Prof. Dr. Saad Suliman

Questionnaire No. ____

Date: 22/04/2015

Section 1: General information

Company name: *Nidukki Trading Co.*

Name of respondent:

Job Title:

Qualification: ☐ Diploma ☐ BSc ☐ MSc ☐ Other (specify)

Telephone (mobile is preferred):

E-mail: *operatives @ nidukki.bh / mahmood @ nidukki.bh*

State the number of years your company has been established as Sewage Collection and Disposal Service Company: *30* *Year's*

Section 2: Company Safety Policy

For the following questions, please tick the appropriate box [Yes], [No]

1- Does the company have a pre-defined transport safety program?

Yes [☒]

No [☐]

2- Are periodic safety meetings held?

Yes [☒]

No [☐]

Please indicate how often meetings are held

Daily [☐] Weekly [☐] Monthly [☒]

3- Is a safety committee established?

Yes [☒]

No [☐]

4- Do you conduct risk assessment analysis prior to attending new trucking orders?

Yes [☐]

No [☒]

5- Do all truck (drivers) get periodical health and safety training?

Yes [☒]

No [☐]

6- Do all truck (drivers) get periodical health check?

Yes [☐]

No [☒]

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1= Very ineffective; 2= Ineffective; 3= Moderately Ineffective; 4= effective; 5= very Effective

7- How effective is the management in considering the suggestions of drivers in route planning?

Rate 1 [☐] 2 [☐] 3 [☐] 4 [☐] 5 [☒]

N/A [☐]

8- How effective is the management in considering the suggestions of drivers in route safety improvements?

Rate 1 [☐] 2 [☐] 3 [☐] 4 [☐] 5 [☒]

N/A [☐]

9- How proactive your company in applying national health and safety procedures ?

Rate 1 [] 2 [] 3 [] 4 [] 5 [✓]

N/A []

Section 2: Journey/Route Planning

For the following questions, please tick the appropriate box [Yes], [No]

1- Does the company have a route/journey management plan?

Yes [✓]

No []

2- Is the route of travel decided according to traffic department accident statistics?

Yes []

No [✓]

3- Does the company have a set job completion target per day?

Yes [✓]

No []

If "Yes", How many? *Varies from location of customer Approx 7-8 loads in one shift.*

4- Are all journeys subject to management approval?

Yes [✓]

No []

Specify All routes taken have to be approved.

5- Are efforts being made to reduce the number of journey to complete jobs?

Yes [✓]

No []

If "No", please state why

6- Is the route clearly defined and mapped?

Yes [✓]

No []

7- Are potential hazards in the route identified?

Yes [✓]

No []

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1= Very ineffective; 2= Ineffective; 3= Moderately Ineffective;
4= effective; 5= very Effective

8- How effective is your communications techniques between the trucks and the operations center during the journey?

Rate 1 [] 2 [] 3 [] 4 [] 5 [✓]

N/A []

Section 3: Accidents

For the following questions, please tick the appropriate box [Yes], [No]

- **By "Accident" we mean collision of the truck where spillage of the load carried by the truck occurs -**

1- Does the company have written accident records?

Yes []

No [✓]

2- What is the average number of accidents for the last:

2 years [.....]

4 years [.....]

6 years [.....]

3- Does the company have written accident recovery procedures?

Yes []

No [✓]

4- Are accident investigation procedures in place?

Yes [✓]

No []

5- Does the company have records of spillage incidents?

Yes []

No [✓]

6- Does the company believe that spillage accidents have a direct impact on the environment?

Yes [✓]

No []

Please explain briefly

Any spillage of hazardous materials can be dangerous for general public. correct action needs to be taken with the involvement of supreme council of environment.

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1= Very ineffective; 2= Ineffective; 3= Moderately Ineffective;
4= effective; 5= very Effective

- 7- How effective are the company's procedures in ensuring that max loads of the truck are not surpassed?

Rate 1 [] 2 [] 3 [] 4 [✓] 5 []

N/A []

- 8- How effective is the company's vehicles inspection and designation procedures?

Rate 1 [] 2 [] 3 [] 4 [✓] 5 []

N/A []

- 9- Are Collection and delivery times logged and communicated with head office?

Rate 1 [] 2 [] 3 [] 4 [✓] 5 []

N/A []

Section 4: Vehicles

For the following questions, please tick the appropriate box [Yes], [No]

- 1- Are all vehicles inspected periodically?

Yes [✓]

No []

Please indicate how often vehicles are checked

Daily [] Weekly [] Monthly [✓]

2- Do all vehicles contain a copy of the safety policies and procedures?

Yes []

No [✓]

3- Does the company have a vehicle spill recovery plan?

Yes [✓]

No []

4- Do you have a pre-trip vehicles check list?

Yes [✓]

No []

Section 5: Operational Costs

For the following questions, please tick the appropriate box:

1- How does the company charge its clients?

Per Job [✓]

Per Load [✓]

Per Distance []

Per Hour [✓]

How much is the average charge? *Varies from Job to Job, considering distance, dumping location etc.*

2- How large do you consider your fleet size?

Small (1- 10 Trucks) []

Medium (10-25 Trucks) []

Large (> 25 Trucks) [☒]

3- How old do you consider your fleet model?

Old (More than 15 years) [☒]

Recent (5 years and less than 15 years) [☒]

New (less than 5 years) [☐]

4- How do you consider your drivers salaries?

Low (1 – 3 BD per hour) [☐]

Average (4 – 6 BD/hour) [☒]

High (>7 BD/hour) [☐]

5- Please state the average for the following:

Driver's years of experience: 5.....

Drivers Age : 35.....

Drivers Working hours per day: 12.....

6- Does the company have a maximum tank load policy for jobs?

Yes [☐]

No [☒]

If "Yes", how much is the maximum load

Section 6: Maintenance Costs

1- How do you consider you staff's driving practices, please rate from 1 to 10,

Rate [7]

N/A []

2- How often is total maintenance carried out on trucks?

After certain km covered:

State Km [.....1500.....]

After certain time elapsed:

State Time [.....]

3- Is periodical maintenance done by service provider?

Yes [✓]

No []

4- Is repair maintenance and spares done in-house?

Yes [✓]

No []

Section 7: Regulations

The following table summarises the related regulations from the *"PUBLIC COMMISSION FOR THE PROTECTION OF MARINE RESOURCES, ENVIRONMENT & WILDLIFE RESOLUTION NO.(3) OF THE YEAR 2006 WITH RESPECT TO THE MANAGEMENT OF HAZARDOUS MATERIALS"*

Place a tick in the "Company's Awareness" column if you believe your company is aware of the regulation listed:

Regulation Section	Discription	Company's Awareness
CH.4 - Article (14)	No natural or corporate person shall carry on the business of transporting hazardous waste without a license in this respect to be issued by the Concerned Directorate.	✓
Ch.4 - Article (17)	1. No hazardous waste shall be transported without being accompanied by a fully completed transportation form from the Generator	✓
	2. No chemical waste shall be transported without being accompanied by a material safety data sheet, subject to complying with the chemical safety requirements laid down by the Concerned Directorate.	✓
	3. No hazardous waste shall be transported unless they are packed in the appropriate manner	✓
	4. Hazardous waste shall not be stored with the carrier.	✓
	5. No hazardous waste shall be transported to a treatment unit or a disposal site that is not licensed by the Concerned Directorate	✓
	6. Warning signs determined by the Concerned Directorate shall be displayed on the transport vehicle.	✓
	7. Waste generated by the spillage of hazardous waste in the course of transportation shall be removed and disposed of in the manner to be decided by the Concerned Directorate.	✓
	8. Hazardous waste being transported shall be re-packed in case drums or tanks are damaged in the	✓

	course of transportation.	✓
	9. Hazardous waste shall not be transported during a peak period.	✓
	10. Hazardous waste shall be returned to the waste generator if such waste is not accepted by the treatment unit, and Paragraph 4 of this Article shall be complied with.	✓

THANK YOU

END OF QUESTIONNAIRE

**University Of Bahrain
College Of Engineering
Department Of Mechanical Engineering**



Questionnaire for studying the risk assessment and management of transportation of raw sewage by trucks

This survey is part of my MSc thesis entitled “**Risk assessment and management of transportation of raw sewage by truck**” to implement/obtain safe management of road transport of sewage in order to reduce the level of accidental risks.

The questions in this survey have been designed to be quick and easy to answer. Completing the survey will help to investigate and study the possibility of accidents and spillages that may occur during transport raw sewage by trucks. This shall present a framework for risk assessment, management and mitigation options.

Please answer each survey question based on your best estimate, drawing upon your professional knowledge and experience. Your response is important to us. If I can assist you in any way, or if you have any questions or comments, please do not hesitate to send an e-mail to fatooma89@hotmail.com or call 33300776.

The information you provide will be held in the strictest confidence. I will not publish, release, or disclose any information identifiable with, company or respondents.

As part of my research I wish to do a small follow up interview, which could be carried out over the telephone or in person. I would be very grateful if you could place your name and a contact email or telephone number.

Thank you very much for your participation

Fatima Hameed Qamber
MSc in Engineering Management Program

Supervisor
Prof. Dr. Elamin M.Elkanzi

Co-Supervisor
Prof. Dr. Saad Suliman

Questionnaire No. ____

Date:

Section 1: General information

Company name:

Name of respondent:

Job Title:

Qualification: ☐ Diploma ☐ BSc ☐ MSc ☐ Other (specify)

Telephone (mobile is preferred):

E-mail:

State the number of years your company has been established as Sewage Collection and Disposal Service Company: ...25... years.

Section 2: Company Safety Policy

For the following questions, please tick the appropriate box [Yes], [No]

1- Does the company have a pre-defined transport safety program?

Yes [☒]

No [☐]

2- Are periodic safety meetings held?

Yes [☒]

No [☐]

Please indicate how often meetings are held

Daily [☐] Weekly [☒] Monthly [☐]

3- Is a safety committee established?

Yes [☒]

No [☐]

4- Do you conduct risk assessment analysis prior to attending new trucking orders?

Yes [☒]

No []

5- Do all truck (drivers) get periodical health and safety training?

Yes [✓]

No []

6- Do all truck (drivers) get periodical health check?

Yes [✓]

No []

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1= Very ineffective; 2= Ineffective; 3= Moderately Ineffective; 4= effective; 5= very Effective

7- How effective is the management in considering the suggestions of drivers in route planning?

Rate 1 [] 2 [] 3 [✓] 4 [] 5 []

N/A []

8- How effective is the management in considering the suggestions of drivers in route safety improvements?

Rate 1 [] 2 [✓] 3 [] 4 [] 5 []

N/A []

9- How proactive your company in applying national health and safety procedures ?

Rate 1 [] 2 [] 3 [✓] 4 [] 5 []

N/A []

Section 2: Journey/Route Planning

For the following questions, please tick the appropriate box [Yes], [No]

1- Does the company have a route/journey management plan?

Yes [✓]

No []

2- Is the route of travel decided according to traffic department accident statistics?

Yes [✓]

No []

3- Does the company have a set job completion target per day?

Yes [✓]

No []

If "Yes", How many? 15.....

4- Are all journeys subject to management approval?

Yes [✓]

No []

Section 3: Accidents

For the following questions, please tick the appropriate box [Yes], [No]

- ***By "Accident" we mean collision of the truck where spillage of the load carried by the truck occurs -***

1- Does the company have written accident records?

Yes [☒]

No [☐]

2- What is the average number of accidents for the last:

2 years [..... ☒]

4 years [.....]

6 years [.....]

3- Does the company have written accident recovery procedures?

Yes [☒]

No [☐]

4- Are accident investigation procedures in place?

Yes [☒]

No [☐]

5- Does the company have records of spillage incidents?

Yes [☒]

No [☐]

6- Does the company believe that spillage accidents have a direct impact on the environment?

Yes [☒]

No [☐]

Please explain briefly

.....
.....
.....

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1= Very ineffective; 2= Ineffective; 3= Moderately Ineffective;
4= effective; 5= very Effective

- 7- How effective are the company's procedures in ensuring that max loads of the truck are not surpassed?

Rate 1 [] 2 [] 3 [] 4 [] 5 [✓]
N/A []

- 8- How effective is the company's vehicles inspection and designation procedures?

Rate 1 [] 2 [] 3 [] 4 [] 5 [✓]
N/A []

- 9- Are Collection and delivery times logged and communicated with head office?

Rate 1 [] 2 [] 3 [] 4 [✓] 5 []
N/A []

Section 4: Vehicles

For the following questions, please tick the appropriate box [Yes], [No]

- 1- Are all vehicles inspected periodically?

Yes [✓]
No []

Please indicate how often vehicles are checked

Daily [☒] Weekly [☐] Monthly [☐]

2- Do all vehicles contain a copy of the safety policies and procedures?

Yes [☒]

No [☐]

3- Does the company have a vehicle spill recovery plan?

Yes [☒]

No [☐]

4- Do you have a pre-trip vehicles check list?

Yes [☒]

No [☐]

Section 5: Operational Costs

For the following questions, please tick the appropriate box:

1- How does the company charge its clients?

Per Job [☐]

Per Load [☒]

Per Distance [☐]

Per Hour [☐]

How much is the average charge? B.D. 10

2- How large do you consider your fleet size?

Small (1- 10 Trucks) [☐]

Medium (10-25 Trucks) [☒]

Large (> 25 Trucks) []

3- How old do you consider your fleet model?

Old (More than 15 years) []

Recent (5 years and less than 15 years) [✓]

New (less than 5 years) []

4- How do you consider your drivers salaries?

Low (1 – 3 BD per hour) [✓]

Average (4 – 6 BD/hour) []

High (>7 BD/hour) []

5- Please state the average for the following:

Driver's years of experience: 1 years.

Drivers Age : up 25 years.

Drivers Working hours per day: 10 Hour.

6- Does the company have a maximum tank load policy for jobs?

Yes [✓]

No []

If "Yes", how much is the maximum load 5 To 10 load.

Section 6: Maintenance Costs

1- How do you consider you staff's driving practices, please rate from 1 to 10,

Rate [5]

N/A []

2- How often is total maintenance carried out on trucks?

After certain km covered:

State Km [10,000]

After certain time elapsed:

State Time [1, month]

3- Is periodical maintenance done by service provider?

Yes [✓]

No []

4- Is repair maintenance and spares done in-house?

Yes [✓]

No []

Specify

5- Are efforts being made to reduce the number of journey to complete jobs?

Yes [☒]

No [☐]

If "No", please state why

6- Is the route clearly defined and mapped?

Yes [☒]

No [☐]

7- Are potential hazards in the route identified?

Yes [☐]

No [☒]

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1= Very ineffective; 2= Ineffective; 3= Moderately Ineffective;
4= effective; 5= very Effective

8- How effective is your communications techniques between the trucks and the operations center during the journey?

Rate 1 [☐] 2 [☐] 3 [☐] 4 [☐] 5 [☒]

N/A [☐]

Section 7: Regulations

The following table summarises the related regulations from the *"PUBLIC COMMISSION FOR THE PROTECTION OF MARINE RESOURCES, ENVIRONMENT & WILDLIFE RESOLUTION NO.(3) OF THE YEAR 2006 WITH RESPECT TO THE MANAGEMENT OF HAZARDOUS MATERIALS"*

Place a tick in the "Company's Awareness" column if you believe your company is aware of the regulation listed:

Regulation Section	Discription	Company's Awareness
CH.4 - Article (14)	No natural or corporate person shall carry on the business of transporting hazardous waste without a license in this respect to be issued by the Concerned Directorate.	
Ch.4 - Article (17)	1. No hazardous waste shall be transported without being accompanied by a fully completed transportation form from the Generator	
	2. No chemical waste shall be transported without being accompanied by a material safety data sheet, subject to complying with the chemical safety requirements laid down by the Concerned Directorate.	
	3. No hazardous waste shall be transported unless they are packed in the appropriate manner	
	4. Hazardous waste shall not be stored with the carrier.	
	5. No hazardous waste shall be transported to a treatment unit or a disposal site that is not licensed by the Concerned Directorate	
	6. Warning signs determined by the Concerned Directorate shall be displayed on the transport vehicle.	
	7. Waste generated by the spillage of hazardous waste in the course of transportation shall be removed and disposed of in the manner to be decided by the Concerned Directorate.	
	8. Hazardous waste being transported shall be re-packed in case drums or tanks are damaged in the course of transportation.	

	9. Hazardous waste shall not be transported during a peak period.	
	10. Hazardous waste shall be returned to the waste generator if such waste is not accepted by the treatment unit, and Paragraph 4 of this Article shall be complied with.	

THANK YOU

END OF QUESTIONNAIRE



Questionnaire for studying the risk assessment and management of transportation of raw sewage by trucks

This survey is part of my MSc thesis entitled “**Risk assessment and management of transportation of raw sewage by truck**” to implement/obtain safe management of road transport of sewage in order to reduce the level of accidental risks.

The questions in this survey have been designed to be quick and easy to answer. Completing the survey will help to investigate and study the possibility of accidents and spillages that may occur during transport raw sewage by trucks. This shall present a framework for risk assessment, management and mitigation options.

Please answer each survey question based on your best estimate, drawing upon your professional knowledge and experience. Your response is important to us. If I can assist you in any way, or if you have any questions or comments, please do not hesitate to send an e-mail to fatooma89@hotmail.com or call 33300776.

The information you provide will be held in the strictest confidence. I will not publish, release, or disclose any information identifiable with, company or respondents.

As part of my research I wish to do a small follow up interview, which could be carried out over the telephone or in person. I would be very grateful if you could place your name and a contact email or telephone number.

Thank you very much for your participation

Fatima Hameed Qamber
MSc in Engineering Management Program

Supervisor
Prof. Dr. Elamin M.Elkanzi

Co-Supervisor
Prof. Dr. Saad Suliman

Questionnaire No. ____

Date:

Section 1: General information

Company name:

Name of respondent:

Job Title:

Qualification: ☐ Diploma ☐ BSc ☒ MSc ☐ Other (specify)

Telephone (mobile is preferred):

E-mail:

State the number of years your company has been established as Sewage Collection and Disposal Service Company: ...4 Years.....

Section 2: Company Safety Policy

For the following questions, please tick the appropriate box [Yes], [No]

1- Does the company have a pre-defined transport safety program?

Yes []

2- Are periodic safety meetings held?

Yes [not regularly]

Please indicate how often meetings are held

Monthly []

3- Is a safety committee established?

No []

4- Do you conduct risk assessment analysis prior to attending new trucking orders?

Yes []

5- Do all truck (drivers) get periodical health and safety training?

Not Periodically but the training is given

- 6- Do all truck (drivers) get periodical health check?
No [but they have an insurance policy]

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1= Very ineffective; 2= Ineffective; 3= Moderately Ineffective; 4= effective; 5= very Effective

- 7- How effective is the management in considering the suggestions of drivers in route planning?

Rate 4[]

- 8- How effective is the management in considering the suggestions of drivers in route safety improvements?

Rate 4[]

- 9- How proactive your company in applying national health and safety procedures ?

Rate 3[]

Section 2: Journey/Route Planning

For the following questions, please tick the appropriate box [Yes], [No]

- 1- Does the company have a route/journey management plan?

Yes []

2- Is the route of travel decided according to traffic department accident statistics?

Yes [Somehow]

3- Does the company have a set job completion target per day?

Yes []

If "Yes", How many? 50 jobs on average.....

4- Are all journeys subject to management approval?

Yes []

5- Are efforts being made to reduce the number of journey to complete jobs?

Yes []

6- Is the route clearly defined and mapped?

No []

7- Are potential hazards in the route identified?

Yes []

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1= Very ineffective; 2= Ineffective; 3= Moderately Ineffective; 4= effective; 5= very Effective
--

- 8- How effective is your communications techniques between the trucks and the operations center during the journey?

Rate 5[]

Section 3: Accidents

For the following questions, please tick the appropriate box [Yes], [No]

- ***By "Accident" we mean collision of the truck where spillage of the load carried by the truck occurs -***

- 1- Does the company have written accident records?

No []

- 2- What is the average number of accidents for the last:

2 years [.....2-3.....]

- 3- Does the company have written accident recovery procedures?

No []

- 4- Are accident investigation procedures in place?

Yes []

- 5- Does the company have records of spillage incidents?

No [Never happened]

- 6- Does the company believe that spillage accidents have a direct impact on the environment?

Yes Somehow

Please explain briefly

because our transportation product is not hazardous,

.....
.....
.....

For the following questions, give a number between 1 and 5 as you feel appropriate. If the question is non-applicable to your company, Tick the N/A box

1= Very ineffective; 2= Ineffective; 3= Moderately Ineffective;
4= effective; 5= very Effective

- 7- How effective are the company's procedures in ensuring that max loads of the truck are not surpassed?

Rate 2[]

- 8- How effective is the company's vehicles inspection and designation procedures?

Rate 2[]

- 9- Are Collection and delivery times logged and communicated with head office?

Rate 3[]

Section 4: Vehicles

For the following questions, please tick the appropriate box [Yes], [No]

- 1- Are all vehicles inspected periodically?

Yes []

Please indicate how often vehicles are checked

Weekly []

- 2- Do all vehicles contain a copy of the safety policies and procedures?

No []

3- Does the company have a vehicle spill recovery plan?
Yes []

4- Do you have a pre-trip vehicles check list?
No []

Section 5: Operational Costs

For the following questions, please tick the appropriate box:

1- How does the company charge its clients?

All the above

How much is the average charge? 15-25 BD.....

2- How large do you consider your fleet size?

Medium (10-25 Trucks) []

3- How old do you consider your fleet model?

Recent (5 years and less than 15 years) []

New (less than 5 years) []

4- How do you consider your drivers salaries?

Low (1 – 3 BD per hour) []

5- Please state the average for the following:

Driver's years of experience: 5.....

Drivers Age : 30.....

Drivers Working hours per day: 12 hrs.....

6- Does the company have a maximum tank load policy for jobs?

No []

If "Yes", how much is the maximum load

Section 6: Maintenance Costs

1- How do you consider you staff's driving practices, please rate from 1 to 10,

N/A []

2- How often is total maintenance carried out on trucks?

After certain km covered: State Km [.....10,000.....]

3- Is periodical maintenance done by service provider?

Yes []

4- Is repair maintenance and spares done in-house?

No []

Section 7: Regulations

The following table summerises the related regulations from the *“PUBLIC COMMISSION FOR THE PROTECTION OF MARINE RESOURCES, ENVIRONMENT & WILDLIFERESOLUTION NO.(3) OF THE YEAR 2006 WITH RESPECT TO THE MANAGEMENT OF HAZARDOUS MATERIALS”*

Place a tick in the “Company’s Awareness” column if you believe your company is aware of the regulation listed:

Regulation Section	Discription	Company’s Awareness
CH.4 - Article (14)	No natural or corporate person shall carry on the business of transporting hazardous waste without a license in this respect to be issued by the Concerned Directorate.	
Ch.4 - Article (17)	1. No hazardous waste shall be transported without being accompanied by a fully completed transportation form from the Generator	
	2. No chemical waste shall be transported without being accompanied by a material safety data sheet, subject to complying with the chemical safety requirements laid down by the Concerned Directorate.	
	3. No hazardous waste shall be transported unless they are packed in the appropriate manner	
	4. Hazardous waste shall not be stored with the carrier.	
	5. No hazardous waste shall be transported to a treatment unit or a disposal site that is not licensed by the Concerned Directorate	
	6. Warning signs determined by the Concerned Directorate shall be displayed on the transport vehicle.	
	7. Waste generated by the spillage of hazardous waste in the course of transportation shall be removed and disposed of in the manner to be	

	decided by the Concerned Directorate.	
	8. Hazardous waste being transported shall be re-packed in case drums or tanks are damaged in the course of transportation.	
	9. Hazardous waste shall not be transported during a peak period.	
	10. Hazardous waste shall be returned to the waste generator if such waste is not accepted by the treatment unit, and Paragraph 4 of this Article shall be complied with.	

THANK YOU

END OF QUESTIONNAIRE

Appendix 2

Second Questionnaire with Sample of Replies

Dear Sir/Madam,

This survey is part of my MSc thesis entitled “**Risk assessment and management of transportation of raw sewage by trucks**” to implement/obtain safe management of road transport of sewage in order to reduce the level of accidental risks.

The questions in this survey have been designed to be quick and easy to answer. Completing the survey will help to investigate and study the possibility of accidents and spillages that may occur during transport raw sewage by trucks. This shall present a framework for risk assessment, management and mitigation options.

Please answer each survey question based on your best estimate, drawing upon your professional knowledge and experience. Your response is important to us. If I can assist you in any way, or if you have any questions or comments, please do not hesitate to send an e-mail to fatooma89@hotmail.com or call 33300776.

The information you provide will be held in the strictest confidence. I will not publish, release, or disclose any information identifiable with, company or respondents.

Thank you very much for your participation

Fatima Hameed Qamber
MSc in Engineering Management Program

Supervisor
Prof. Dr. Elamin M.Elkanzi

Co-Supervisor
Prof. Dr. Saad Suliman

General information

Name of respondent:

Job Title:

Qualification: ☐ Diploma ☐ BSc ☐ MSc ☐ Other (specify)

Telephone (mobile is preferred):

E-mail:

This questionnaire is a professional version of an earlier questionnaire distributed around to sewerage trucking companies. I have re-organized the questions in order to get your expert feedback and assistance in prioritizing the factors in each section.

Section 1: Safety Policy Compliance

Please arrange the following factors (**in order from 1 to 6**) as you consider how they prioritize over each other:

Factor	Priority
Availability of predefined transport safety program	
Holding periodic safety meetings	
Established safety committee	
Conducting risk assessment analysis prior to new trucking orders	
Conducting periodic health & safety training for drivers	
Carrying periodical health check for drivers	

Section 2: Route Planning Effectiveness

Please arrange the following factors (**in order from 1 to 7**) as you consider how they prioritize over each other:

Factor	Priority
Availability of route/journey management plan	
Use of accident statistic in route planning	
Completing the target no. of journeys per day	
Subjecting all journeys to managerial approval	
Imposing efforts to reduce the no. of journeys per job	
Clearly defined and mapped routes	
Identifying potential hazards in the route	

Section 3: Accident Management

Please arrange the following factors (**in order from 1 to 4**) as you consider how they prioritize over each other:

Factor	Priority
Availability of Accident records	
Availability of accident recovery procedure	
Availability of accident investigation procedure	
Availability of accident spillage incident records	

Section 4: Vehicle Reliability:

Please arrange the following factors (**in order from 1 to 4**) as you consider how they prioritize over each other:

Factor	Priority
Vehicle periodical inspections	
Availability of safety policy and procedure in vehicle	
Availability of vehicle spill recovery plan	
Availability of pre-trip vehicle check list	

Dear Sir/Madam,

This survey is part of my MSc thesis entitled “**Risk assessment and management of transportation of raw sewage by trucks**” to implement/obtain safe management of road transport of sewage in order to reduce the level of accidental risks.

The questions in this survey have been designed to be quick and easy to answer. Completing the survey will help to investigate and study the possibility of accidents and spillages that may occur during transport raw sewage by trucks. This shall present a framework for risk assessment, management and mitigation options.

Please answer each survey question based on your best estimate, drawing upon your professional knowledge and experience. Your response is important to us. If I can assist you in any way, or if you have any questions or comments, please do not hesitate to send an e-mail to fatooma89@hotmail.com or call 33300776.

The information you provide will be held in the strictest confidence. I will not publish, release, or disclose any information identifiable with, company or respondents.

Thank you very much for your participation

Fatima Hameed Qamber
MSc in Engineering Management Program

Supervisor
Prof. Dr. Elamin M.Elkanzi

Co-Supervisor
Prof. Dr. Saad Suliman

General information

Name of respondent: Kate Elsworth

Job Title: Principal Environmental Consultant

Qualification: ☐ Diploma ☐ BSc ☒ MSc ☐ Other (specify)

Telephone (mobile is preferred): 39976359

E-mail: kate@environmentarabia.com

This questionnaire is a professional version of an earlier questionnaire distributed around to sewerage trucking companies. I have re-organized the questions in order to get your expert feedback and assistance in prioritizing the factors in each section.

Section 1: Safety Policy Compliance

Please arrange the following factors (**in order from 1 to 6**) as you consider how they prioritize over each other:

Factor	Priority
Availability of predefined transport safety program	1
Holding periodic safety meetings	6
Established safety committee	5
Conducting risk assessment analysis prior to new trucking orders	4
Conducting periodic health & safety training for drivers	2
Carrying periodical health check for drivers	3

Section 2: Route Planning Effectiveness

Please arrange the following factors (**in order from 1 to 7**) as you consider how they prioritize over each other:

Factor	Priority
Availability of route/journey management plan	2
Use of accident statistic in route planning	6
Completing the target no. of journeys per day	7
Subjecting all journeys to managerial approval	1
Imposing efforts to reduce the no. of journeys per job	4
Clearly defined and mapped routes	5
Identifying potential hazards in the route	3

Section 3: Accident Management

Please arrange the following factors (**in order from 1 to 4**) as you consider how they prioritize over each other:

Factor	Priority
Availability of Accident records	4
Availability of accident recovery procedure	1
Availability of accident investigation procedure	2
Availability of accident spillage incident records	3

Section 4: Vehicle Reliability:

Please arrange the following factors (**in order from 1 to 4**) as you consider how they prioritize over each other:

Factor	Priority
Vehicle periodical inspections	1
Availability of safety policy and procedure in vehicle	3
Availability of vehicle spill recovery plan	4
Availability of pre-trip vehicle check list	2

Dear Sir/Madam,

This survey is part of my MSc thesis entitled “**Risk assessment and management of transportation of raw sewage by trucks**” to implement/obtain safe management of road transport of sewage in order to reduce the level of accidental risks.

The questions in this survey have been designed to be quick and easy to answer. Completing the survey will help to investigate and study the possibility of accidents and spillages that may occur during transport raw sewage by trucks. This shall present a framework for risk assessment, management and mitigation options.

Please answer each survey question based on your best estimate, drawing upon your professional knowledge and experience. Your response is important to us. If I can assist you in any way, or if you have any questions or comments, please do not hesitate to send an e-mail to fatooma89@hotmail.com or call 33300776.

The information you provide will be held in the strictest confidence. I will not publish, release, or disclose any information identifiable with, company or respondents.

Thank you very much for your participation

Fatima Hameed Qamber
MSc in Engineering Management Program

Supervisor
Prof. Dr. Elamin M.Elkanzi

Co-Supervisor
Prof. Dr. Saad Suliman

General information

Name of respondent: **Kay-Uwe Bohlen**

Job Title: **Chief Project Team Muharraq STP**

Qualification: ☐ Diploma ☐ BSc ☐ MSc ☒ Other (specify) **Diplom-Ingenieur Universitaet**

Telephone (mobile is preferred): **393 024 93**

E-mail: **kay-uweBohlen@works.gov.bh**

This questionnaire is a professional version of an earlier questionnaire distributed around to sewerage trucking companies. I have re-organized the questions in order to get your expert feedback and assistance in prioritizing the factors in each section.

Section 1: Safety Policy Compliance

Please arrange the following factors (**in order from 1 to 6**) as you consider how they prioritize over each other:

Factor	Priority
Availability of predefined transport safety program	1
Holding periodic safety meetings	4
Established safety committee	6
Conducting risk assessment analysis prior to new trucking orders	2
Conducting periodic health & safety training for drivers	3
Carrying periodical health check for drivers	5

Section 2: Route Planning Effectiveness

Please arrange the following factors (**in order from 1 to 7**) as you consider how they prioritize over each other:

Factor	Priority
Availability of route/journey management plan	1
Use of accident statistic in route planning	5
Completing the target no. of journeys per day	6
Subjecting all journeys to managerial approval	2
Imposing efforts to reduce the no. of journeys per job	4
Clearly defined and mapped routes	7
Identifying potential hazards in the route	3

Section 3: Accident Management

Please arrange the following factors (**in order from 1 to 4**) as you consider how they prioritize over each other:

Factor	Priority
Availability of Accident records	1
Availability of accident recovery procedure	4
Availability of accident investigation procedure	3
Availability of accident spillage incident records	2

Section 4: Vehicle Reliability:

Please arrange the following factors (**in order from 1 to 4**) as you consider how they prioritize over each other:

Factor	Priority
Vehicle periodical inspections	1
Availability of safety policy and procedure in vehicle	2
Availability of vehicle spill recovery plan	3
Availability of pre-trip vehicle check list	4

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This survey is part of my MSc thesis entitled “**Risk assessment and management of transportation of raw sewage by trucks**” to implement/obtain safe management of road transport of sewage in order to reduce the level of accidental risks.

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Supervisor
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Co-Supervisor
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General information

Name of respondent: Binu Mathew

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Section 1: Safety Policy Compliance

Please arrange the following factors (**in order from 1 to 6**) as you consider how they prioritize over each other:

Factor	Priority
Availability of predefined transport safety program	1
Holding periodic safety meetings	5
Established safety committee	4
Conducting risk assessment analysis prior to new trucking orders	2
Conducting periodic health & safety training for drivers	3
Carrying periodical health check for drivers	6

Section 2: Route Planning Effectiveness

Please arrange the following factors (**in order from 1 to 7**) as you consider how they prioritize over each other:

Factor	Priority
Availability of route/journey management plan	1
Use of accident statistic in route planning	7
Completing the target no. of journeys per day	3
Subjecting all journeys to managerial approval	4
Imposing efforts to reduce the no. of journeys per job	5
Clearly defined and mapped routes	6
Identifying potential hazards in the route	2

Section 3: Accident Management

Please arrange the following factors (**in order from 1 to 4**) as you consider how they prioritize over each other:

Factor	Priority
Availability of Accident records	3
Availability of accident recovery procedure	1
Availability of accident investigation procedure	2
Availability of accident spillage incident records	4

Section 4: Vehicle Reliability:

Please arrange the following factors (**in order from 1 to 4**) as you consider how they prioritize over each other:

Factor	Priority
Vehicle periodical inspections	2
Availability of safety policy and procedure in vehicle	1
Availability of vehicle spill recovery plan	3
Availability of pre-trip vehicle check list	4

Dear Sir/Madam,

This survey is part of my MSc thesis entitled “**Risk assessment and management of transportation of raw sewage by trucks**” to implement/obtain safe management of road transport of sewage in order to reduce the level of accidental risks.

The questions in this survey have been designed to be quick and easy to answer. Completing the survey will help to investigate and study the possibility of accidents and spillages that may occur during transport raw sewage by trucks. This shall present a framework for risk assessment, management and mitigation options.

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MSc in Engineering Management Program

Supervisor
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General information

Name of respondent:

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This questionnaire is a professional version of an earlier questionnaire distributed around to sewerage trucking companies. I have re-organized the questions in order to get your expert feedback and assistance in prioritizing the factors in each section.

Section 1: Safety Policy Compliance

Please arrange the following factors (**in order from 1 to 6**) as you consider how they prioritize over each other:

Factor	Priority
Availability of predefined transport safety program	4
Holding periodic safety meetings	2
Established safety committee	1
Conducting risk assessment analysis prior to new trucking orders	6
Conducting periodic health & safety training for drivers	3
Carrying periodical health check for drivers	5

Section 2: Route Planning Effectiveness

Please arrange the following factors (**in order from 1 to 7**) as you consider how they prioritize over each other:

Factor	Priority
Availability of route/journey management plan	4
Use of accident statistic in route planning	6
Completing the target no. of journeys per day	7
Subjecting all journeys to managerial approval	3
Imposing efforts to reduce the no. of journeys per job	5
Clearly defined and mapped routes	1
Identifying potential hazards in the route	2

Section 3: Accident Management

Please arrange the following factors (**in order from 1 to 4**) as you consider how they prioritize over each other:

Factor	Priority
Availability of Accident records	2
Availability of accident recovery procedure	3
Availability of accident investigation procedure	4
Availability of accident spillage incident records	1

Section 4: Vehicle Reliability:

Please arrange the following factors (**in order from 1 to 4**) as you consider how they prioritize over each other:

Factor	Priority
Vehicle periodical inspections	2
Availability of safety policy and procedure in vehicle	4
Availability of vehicle spill recovery plan	3
Availability of pre-trip vehicle check list	1

ملخص البحث

على الرغم من التطور الملحوظ في معالجة مياه الصرف الصحي في مملكة البحرين، إلا إنه لا يزال هناك بعض المناطق التي لا تتصل بشبكة نقل مياه الصرف الصحي. ومن ثم يستوجب استخدام الشاحنات لنقل مياه الصرف الصحي. إن زيادة عدد السكان و التطور العمراني في مملكة البحرين قد يزيد من عدد الشاحنات الناقلة لمياه الصرف الصحي و بالتالي فإن النقل اليومي من مياه الصرف الصحي سواء لمحطة توبلي أو المحرق لمعالجة مياه الصرف الصحي قد يتسبب في خلق مخاطر من ناحية الأمن و السلامة و ذلك عن طريق حدوث الانسكاب وألحوادث المرورية. ويمكن لهذه الحوادث أن يكون لها تأثيرات بيئية وصحية سلبية على المنطقة القريبة من وقوع الحادث. فبالتالي تبقى الشاحنات الناقلة لمياه الصرف الصحي مصدر قلق للمجتمع و ينبغي معالجتها عن طريق دراسة تقييم ممارسات الشركات الناقلة لمياه الصرف الصحي لتصبح وسيلة نقل آمنة وصحية وفعالة. فقد أجريت زيارات ميدانية لعدد من الشركات الناقلة لمياه الصرف الصحي، والسلطات والبلديات ذات الصلة إلى جانب توزيع استبيان على جميع شركات النقل المدرجة في المملكة من أجل جمع البيانات اللازمة لإجراء التقييم على أساس العوامل المختارة التي تم استنتاجها من مراجعة مجموعة واسعة من الأدبيات الدولية حول هذا الموضوع. وقد تم اختيار أربعة عوامل رئيسية لتشكيل نموذج شامل لتقييم سلامة نقل مياه الصرف الصحي بواسطة الشاحنات تتمثل في: الامتثال لسياسة السلامة، فعالية تخطيط اختيار الطريق، كفاءة ادارة الحوادث وضمان جودة المركبات. و قد أجري تحليل للناتج التي تم الحصول عليها من الاستبيان من خلال استخدام المنهج الوصفي والكمي (استخدام المؤشرات) لمعرفة مدى امتثال الشركات الناقلة لمياه الصرف الصحي لهذه العوامل. كما شملت الدراسة أيضا رسم خرائط السلامة لتصور نتائج تقييم عوامل نموذج السلامة، ويعتبر هذا النهج جديد في تحليل السلامة. كما أن استخدام المؤشرات في تحليل كل من أسئلة الاستبيان يعتبر أيضاً نهج و اسلوب جديد في التحليل. و بالتالي كلا المنهجين يمثلان مساهمة رئيسية في دراسات السلامة. وكانت النتائج المستخلصة من الدراسة تتمثل في : أن شركات النقل ذات الحجم الكبير للأسطول تدعم مبادئ السلامة أكثر من الشركات الأصغر حجماً، و أن شركات النقل تركز على احتياجات عملائها وتتجاهل متطلبات السلامة. كما تم اقتراح نموذج لتقييم السلامة من أجل تقييم مستوى أداء السلامة من جانب شركات الناقلة لمياه الصرف الصحي بواسطة الشاحنات . و في الختام تم اقتراح توصيات لتحسين وتنظيم وسيلة نقل مياه الصرف الصحي بواسطة الشاحنات أبرزها تنظيم الجهات المسؤولة الشاحنات الناقلة للمياه الصرف الصحي وفقاً للمعايير الدولية وإدراجها تحت مظلة نقل المواد الخطرة في مملكة البحرين. والتوصية الرئيسية التي تم استخلاصها هي أن النموذج المقترح يمكن استخدامه كأساس لوضع قائمة شاملة للتحقق من الامتثال للسلامة من قبل السلطات وشركات النقل. و تأمل الدراسة أن يساهم هذا النموذج في تنظيم هذه المشكلة على المستوى الوطني.

جامعة البحرين

قسم الهندسة الميكانيكية

كلية الهندسة



تقييم سلامة نقل مياه الصرف الصحي بواسطة الشاحنات

بحث لاستكمال متطلبات الحصول على درجة (الماجستير) في برنامج الإدارة الهندسية

إعداد

فاطمة حميد قمبر ابراهيم

الرقم الجامعي: 20061078

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جامعة البحرين

مملكة البحرين

يناير 2017