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Can trade effluent charges promote compliance and address water security risks in Nairobi's manufacturing industries?

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by

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ABSTRACT

This research assessed whether trade effluent charges could promote compliance and address water security risks in manufacturing industries in Nairobi. This is due to the burden of effluent management that Nairobi City Water and Sewerage Company (NCWSC), the largest water supply and sewerage Company in Nairobi, has been having in the management of effluent water despite the existence of comprehensive effluent discharge regulations. The research therefore assessed the water security risks faced by manufacturing companies and assessed the compliance rates of manufacturing companies with effluent waste water discharge regulations, to find out whether there is any effects on water security brought about by the trade effluent charges and to determine the effects of these charges on operational performance of Nairobi City Water and Sewerage Company. A descriptive survey was used to carry out this research targeting a sample of twenty (20) manufacturing companies in Nairobi County spread across different sectors such as textile, agro-processing, oils and refinery and food and beverage.

The research results reveal that most industries in Nairobi County consume between 10,001 to 50,000 m^3 of water monthly and that most them are compliant with NEMA effluent discharge regulations. The research further showed that compliance with the set regulations have been on a steady increase from the year 2015 to 2017. On water security risks, the research established that manufacturing industries have been discharging a varying amount of effluent into the sewers of Nairobi city and most of them invest in various water efficiency measures to reduce water usage and comply with effluent discharge regulations. The research further established that NEMA effluent discharge regulations have had no effect on their operational performance of most industries in Nairobi County as the cost of effluent discharge is part of their budget. Additionally NEMA effluent discharge regulations had no effect on the water security risks of the manufacturing industries, in most manufacturing industries since most of them invested in

drilling boreholes and rain water harvesting before the regulations were enacted to supplement water supply while for the remaining few, the said regulations had increased their water security by encouraging them to recycle water, invest in rain water harvesting and also utilize less borehole water.

In conclusion, the introduction of the trade waste effluent regulations has had minimal effect in promoting treatment and recycling of waste water, reduction of costs in operation of municipal treatment plants and their maintenance and mitigation of water security risks. To promote compliance of regulations and investment in waste water treatment and reuse to address water security risks from demand side management, policy makers need to design incentives to compel large water users to invest in demand side management measures. These measures could include waste water treatment and reuse, water reduction interventions, measuring and monitoring water use. On the other hand corporate management need to incorporate water-use efficiency measures, sustainability and environmental protection within their strategies.

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GLOSSARY OF TERMS

BOD – Biological Oxygen Demand

EMCA – Environmental and Management Conservation Act

GDP – Gross Domestic Product

MIBs – Market Based Instrument

M^3 – cubic metres

NCWSC – Nairobi City Water and Sewerage Company

NEMA – national Environmental authority

OECD – Organization for Economic Development

STPs – Sewage Treatment Plants

TSS – Total Suspended solids

WRA – water Resource Authority

CHAPTER ONE

1. INTRODUCTION AND BACKGROUND OF THE RESEARCH

Water security as defined by the UN water, refers to the capacity of a population to protect sustainable access to adequate quantities of water that is of acceptable quality for sustaining livelihoods, human well-being and socio-economic development (UN Water, 2013). Globally, it is estimated that the world will face a 40% gap between demand and supply of water predicting a looming water scarcity problem. As stated by the 2030 Water Resources Group, by 2030, considering an average scenario in economic growth and if assuming no efficiency gains, water requirements would grow from 4,500 billion m^3 to 6,900 billion m^3 globally. This is above the current accessible reliable supply including return flows by 40 percent (2030 Water Resource Group, 2009).

Water consumption trends show that by far, the largest consumer of water is agriculture, at an aggregate level of 70% globally while industry stands at an average of about 28% and then followed by municipal water use, otherwise also referred to as domestic water use. (2030WRG). In looking at industrial sector's water consumption, Lloret and Water, (2010) observed that water plays three roles, and each role requires a different approach to strategic management. One, water is a raw material input for most industries, examples being chemicals and food processing and beverages. Two, water is a source of energy in hydro-power generation, mining and nuclear plants and in these two roles, industry always pays a price that is driven by market conditions. Third and of interest for this research is that, water is a by-product of most industrial processes and is discharged as waste water or effluent water. Depending on the nature of this discharge, waste water discharged could have pollution potential, from sectors such as textiles, leather, steel and automotive industries (Lloret & Water, 2010).

Industries and companies use and produce a lot of toxic liquids into municipal sewer systems, and to the environment through discharge to surface water or underground water sources. In china, the quantity of untreated industrial wastewater discharged has been decreasing since 2008 (National Bureau of Statistics of China, 2013). This is due to two main initiatives which were put in place from the 12th Five Year Plan. The five- year plan increased government spending on environmental protection whereby more stringent regulations were put in place to penalise heavy polluters (Chen, Geng & Fujita, 2010). Some of the key water quality indicators that were monitored under the Five-Year Plan were COD, NH_4, Total Nitrogen, Phosphorous, Petroleum, Volatile Phenol, Lead, Mercury, Cadmium, Hexavalent Chromium, Total Chromium and Arsenic. In China these standards vary across the country with some regions developing their own local discharge standards for water pollutants, particularly in areas such as Beijing, Guangdong and Shanghai. The urban areas with more stringent standards tend to have a higher GDP, resulting in more municipal funding to improve sewage treatment capabilities and availability (Pandit, Minne, Li, Brown, & Jeong, 2015).

Whenever industries discharge heavily contaminated effluent water to the piped or sewerage network, this increases the cost of treatment of the effluent at the sewage treatment plants. It also leads to high operation and maintenance costs as well as poor quality of treated effluent leaving the treatment plant and being discharged into the environment, in other words environmental pollution. Managing environmental problems such as water pollution or air pollution efficiently, requires well-designed public policies and coordination among stakeholders (Ostrom, 2015). Environmental policies aim to bring down degradation of the environment at the lowest social cost that is possible. One way of achieving this is by aligning the social costs with those that are private by ensuring that externalities are included in the decision making. Several policies include development of specific pollution charges such as sewerage charges or effluent charges. The amount paid for indirect discharges such as domestic sewage or waste discharged as effluent into the sewer system is referred to as sewerage charge (Hansen et al., 2001). The charges target to provide environmental authorities with financial resources to manage water resources activities (financial function) (Kraemer, Kampa, & Interwies, 2004). On the other hand, those who discharge effluent into natural waters pay effluent charges either to a parastatal or a public authority. (Hansen et al., 2001). These charges are mostly on the basis of measurements or estimates of the quantity and quality of a pollutant released to the environment or natural water bodies and not to a sewer system.

Goal number 7 of the Millennium Development Goals (MDGs), which are now superseded by the Sustainable Development Goals (SDGs) (Weitz et al., 2014), required actors to ensure environmental sustainability. This goal challenged the world to reduce the proportion of people who lack access to sustainable safe drinking water and sanitation by half by the year 2015, (UNICEF and WHO, 2015). Vörösmarty et al. (2010) showed that, in 2010 almost 80% of the population in the entire world was exposed to high levels of water insecurity despite the need to increased access to safe drinking water. This was regarded as the antipodal to water security. While a lot of investment in different water technologies have made it possible for wealthy nations to reduce their high stressor levels over the last twenty years without solving their underlying causes, the poorer countries continue to be vulnerable (UNICEF and WHO, 2015). This is especially true in Africa, where many regions mostly in rural areas continue to display the lowest coverage of water supply globally. Half of the population in 2015, which was roughly 663 million people worldwide that are still using unimproved sources of drinking water live in sub-Saharan Africa. A bigger concern is the fact that there continues to be a significant risk posed to public health in the developing world brought about by diseases associated with poor water and sanitation (UNICEF and WHO, 2015).

In South Africa, the condition of bulk water and waste water infrastructure and the impacts of pollution represent serious concerns (HRC, 2014). Rivers are mainly experiencing pollution from electricity production and acid mine drainage which stems from mining activities in the lower northern regions of the country (Coetzee et al., 2010; Pheiffer et al., 2014). Surface water quality is also threatened by excessive nutrient inflow, mainly from domestic effluent in many parts of the country (untreated wastewater) and industrial and sewage effluent (treated wastewater from sewage treatment works), run-off from agricultural lands and uncontrolled disposal of wastewater from informal settlements (Nyenje, et al., 2010).

In Nigeria, a research by Longe and Ogundipe (2012) on wastewater discharge impact from the University of Lagos campus treatment plant on the lagoon system revealed that average removal efficiencies of measured parameters from treated effluents are 26% for Total Dissolved Solids (TDS), 73% for Biological Oxygen Demand (BOD), 65.8% for Chemical Oxygen Demand (COD) and 72% for Total Nitrogen (Total N) for the wet season. During the dry season average removal efficiencies of measured parameters are 54% for TDS, 54% for BOD, 39% for COD and 42% for Total N. These values were lower than values obtained for the wet season except for TDS. Most parameters in effluents exceeded the National Environmental Protection Regulations, Effluent Limitation standards for discharge into river bodies. Average concentrations of TDS, BOD and COD in lagoon water show higher concentrations than in the treated effluent and are above the regulatory requirements.

In Aba, one of Nigeria's commercial cities, Odurukwe (2012), reported that there is no central wastewater system, and there are no septic tanks for domestic wastewater. The sewers for industrial wastewater coming from big industries and the open drains used for the wastewater of medium and small scale industries are channelled in such a way that their contents are emptied into Aba River. The research further showed that there was inadequate or hardly any treatment of the wastewater produced by the industries, and no efforts were being made to change this situation. Further, as a result of its large-scale commercial activity, particularly manufacturing, industries in Lagos generate vast quantities of industrial wastewater. Industrial wastewater is very concerning because of its high concentration of toxic compounds employed within manufacturing and other industrial processes, and because industry operators discharge these effluents into the environment with minimal treatment. Untreated wastewater discharged into the environment constitutes a threat to human and ecological health (Oteri, 2013).

In Kenya, renewable internal freshwater supply per capita is only 461 cubic meters (Gustaffson & Davies, 2015). At these levels, Kenya faces absolute water scarcity, as defined by the United Nations which states that renewable internal freshwater supply below 1,000 cubic metres per capita is categorized as absolute scarcity. A key sector in the Kenyan economy, manufacturing industry contributes 21 percent of national gross domestic product. Kenya's Vision 2030 aims to develop the sector further by creating a robust, diversified, and competitive manufacturing sector expected to contribute an additional 10 percent to GDP (The Ministry of Planning and Devolution, 2007). To accommodate this growth, industrial demand on the country's water resources will increase significantly. A research by Miruka (2016) on the efficiency of Nairobi's Kariobangi Wastewater treatment plant established that the quality of the effluent that emanated from the plant was wanting and the pollution load discharged into Nairobi River was in large figures.

1.1. Problem statement

Kenya is a fast growing country and categorised as an upper low income country according to (Copley, 2014) who stated that Kenya is the ninth-largest economy in Africa and is now classified as a middle-income country since its gross national income (GNI) per capita, $1,160, surpassed the World Bank threshold of $1,036 to qualify in 2014. While this is attractive and enables Kenya to attract commercial financing at lowers rates, it also means that there will be increased investments in the country. With the increased foreign and local direct investment and climate change effects on the other hand, water demand is expected to grow significantly, thereby putting a strain on the existing resources. Alternative sources of water need to be sought as well as water-use-efficiency in order to address this challenge. At NCWSC, untreated industrial and trade effluents have a negative impact on the flow of the sewerage system and disrupt the treatment processes of Sewage Treatment Plants (STPs) due to the heavy pollutant loads. The blockages impact on the operational and maintenance costs and corporate image, whilst the pollution loads to the treatment efficiency of the receiving STPs. All these costs are borne by the company while the producers of the pollutants only pay for effluent volumes at the same rate as domestic sources who in many cases are compliant with the discharge standards.

In line with Stavins, (2003) recommendations, NCWSC recently introduced the trade effluent charge as a way to promote compliance as well as encourage treatment of effluent before its discharge or its reuse. This regulation is new and was introduced to the trade clients who are either industries or large commercial water users. This charge is in addition to its usual tariff for sewerage services. Each industry discharges some amount of waste into the NCWSC sewer system. However, in most cases, this effluent does not meet the minimum required standards of quality. These quantities of pollutants over and above the minimum discharge standard are then used by NCWSC to calculate the trade waste charge. Apart from the toxic effluents discharged into the sewer systems in Nairobi, the County struggles with the provision of clean water to County residents as water levels in dams are often low. Charges and or cost for renewing wastes generated from domestic and industrial sources have at the same time been too high for NCWSC to incur alone. This is a clear indication that the companies often dispose off their toxic wastes without adhering to set regulations. The current research therefore assessed how the introduction of trade effluent charges affect compliance and water security in Nairobi County as no research has addressed this yet.

1.2. Research objectives and hypotheses

This paper has established the extent to which introduction of the market-based instrument – trade effluent charge – has affected the operational performance of NCWSC maintenance of the sewage treatment plant and whether the charges have promoted compliance of regulations and to what extent they have addressed water security challenges for manufacturing industries in Nairobi.

1.2.1. Objectives:

The objectives of this research are:

i. To assess the water security risks faced by manufacturing companies within Nairobi City Kenya
ii. To determine the compliance rates of manufacturing companies with effluent waste water discharge regulations within Nairobi City in Kenya
iii. To find out the effects of trade effluent charges on water security within Nairobi City in Kenya
iv. To determine the effects of trade effluent charges on operational performance of Nairobi City Water and Sewerage Company

1.2.2. Hypothesis:

Literature studies indicate that market-based instruments such as trade effluent charges change behavioural partners. In many water scarce countries such as Kenya, the government has introduced various incentives, market-based instruments and control and measure tools to promote investment in water efficiency and conservation as a way to address the water security risks for business. Investment in water efficiency and pollution prevention initiatives do not have a strong business case for large water users, by companies and business to invest in. It is with this premise that this research aims to determine whether the introduction of trade effluent charges as a market-based instrument have influenced investment in water efficiency to address water security challenges.

Additionally, in most markets, water is undervalued and most corporates operate on the premise that the resource is cheap and always available, however, with the recent developments and changes in climate patterns such as more severe droughts and increased demand for water, it is expected that businesses will comply with regulations to prevent pollution of the resource in order to ensure its sustainability, however whether this translates to benefits to the water service providers who manage the treatment of effluent before discharge is a question that this research seeks to answer in its second hypothesis.

These two issues identified above have led to the selection of the following hypothesis;

i. There is no significant relationship between trade effluent charges and water security in Nairobi County Kenya

ii. There is no significant relationship between trade effluent charges and performance of the operations at Nairobi City Water and Sewerage Water Company

1.3. Justification of the research

This research is useful for Nairobi Water Company as it helps to ascertain whether introduction of the effluent charge has helped to reduce operation and maintenance costs of the sewerage system, improve the quality of water received at its effluent treatment plants and thereby also improving the efficiency of the treatment plant. The findings of the research have also helped to determine whether the effluent charges have addressed water security risks for industries by reducing their demand for fresh water supply from NCWSC and thereby allowing them to use the same resource to increase its fresh water supply coverage to other new consumers.

For Kenya as a country, pollution of the water resources is a major concern and the success of these effluent discharge regulations could be replicated to the other water supply providers, thereby helping address the challenge of environmental pollution and water security.

Being the largest city in Kenya with the highest concentration of manufacturing industries, using 20 manufacturing industries as the sample size provides a good variety of manufacturing industries with different needs when it comes to compliance and effluent water management. It also provides a complex environment with different scenarios in terms of availability of abatement solutions for effluent management and constraints such as lack of sufficient space for industries to invest in the abatement solutions. Therefore, the success or failure of the trade effluent charge provides a strong basis for either its replication elsewhere in the country or not.

1.4. Organization of the Research

This research was organized in five chapters. The first chapter presents an introduction to the global, regional and Kenyan water context, highlighting the most water consumptive sectors and industrial water usage trends. It also provides an overview of industrial water and effluent management in other countries and a brief description of the motivation towards introduction of the trade effluent charge in Kenya is made. The chapter then highlights the problem statement, the research objectives, hypothesis and the justification for the research. It concludes by providing a justification and organization of the research.

In the second chapter, the research delved into relevant literature starting with an empirical review of literature in water security risks faced by manufacturing industries, the different trade waste charges that industries encounter in different countries, compliance of effluent water regulations and effects of trade effluent charges on water security and the effect that these charges have had on performance of municipal waste water treatment plants. In the same section, a few examples were examined to provide a perspective of areas where the trade effluent regulations have worked and where it has not worked. In the theoretical literature review, the research reviews the stakeholders' theory and thereafter concludes with the conceptual framework and how it has been applied in this research.

In Chapter three, the research methodology used in the research is described, providing details of the choice of the sampling design and the target population. A description of the sampling techniques and sample size are also described. The research then focuses on describing the research instruments used, the data collection and data analysis techniques used. At the end of the chapter, the research validity and reliability is provided.

In Chapter four, the data collected is analysed against the research objectives and the hypothesis set out in Chapter one. The findings of the analysis are also presented in this chapter linking with the relevant empirical literature, theories and conceptual frameworks mentioned in the literature review. The limitations encountered during the research are also mentioned in this chapter.

Finally, in Chapter five, we present the conclusions derived from the findings and analysis in the previous chapter. The recommendations for further studies, policy interventions and corporate management decisions are also presented in this chapter. The researcher also highlights the limitation encountered during the research.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Introduction

In this section the researcher conducted an empirical review of literature on the research topic guided by the following subheadings, water security risks faced by manufacturing industries, trade waste effluent charges, effects of trade effluent charges on water security, compliance with effluent water discharge regulations by manufacturing companies and ends with effect of trade effluent charges on operational performance of the water supply and sewerage service company. This is followed by the theoretical and conceptual frameworks.

2.2. Empirical Literature Review

In the empirical literature review, the research looked at the water security risks faced by manufacturing industries as one key aspect that compels industries to invest in sustainable water management and pollution prevention. In many parts of the world, water is undervalued, however, the threat of its availability leads to industries investing in its sustainable use and pollution prevention. The research also looks at compliance of effluent discharge regulations since, whenever voluntary initiatives do not generate the results expected, policy makers result to regulations to promote compliance, such as in this case. There are other areas that it could have looked at such as economic incentives and other command and control tools used to address water security risks however, it was limited researchto compliance of regulations, however, currently there are no incentives provided for business and manufacturing companies to compel them to invest in water security measures and therefore looking at use of the recently introduced trade waste effluent charges was the most relevant aspect for the chosen research area, Nairobi.

2.2.1. Water security risks faced by manufacturing industries

Water security risk is a problem facing governments' world over with the ever-increasing need for the commodity caused by population growth, urbanization and climate change. According to Yong (2015), China has been facing increasingly severe water scarcity that seriously threatens the socio-economic development and sustainability of the country's water resources In China, the issue is two-sided, one side is such that its per capita water availability is not evenly distributed in both spatially and temporally, making it inconsistent with increasing socio-economic water requirement; on the other side, inefficient use, wastage, and pollution are the norm and have been negatively affecting the performance of water systems to sustain China's socio-economic development (Yong, 2015).

Wastewater discharges further threaten water security by polluting limited available freshwater. China's wastewater discharge has been steadily increasing since 1990, particularly after 1998. As of 2012, the total amount of wastewater discharged reached nearly 70 billion m^3 (Yong, 2015). In 2015, Yong adds that, across many years, wastewater discharged from industry fluctuated and has been reducing recently, with its proportion of total wastewater discharge also reducing. Chemical Oxygen demand (COD)'s discharge of chemical gradually reduced until 2010, and then sharply increased as a result of change in the method of calculating pollution calculation which brought in agricultural discharges from 2011 (Yong, 2015).

Rodda, Stenström, Schmidt, Dent, Bux, Hanke, Buckley and Fennemore, (2016) studied water security in South Africa and established that South Africa is a water-scarce country with increasing pressure on its water resources. In Nigeria, effluent discharges from domestic, municipal, trade, industrial and agricultural set-ups which contain various pollutants including heavy metals have been transported in untreated forms into water bodies through drains, water-ways and soils into inland water-bodies (Oguzie & Okosodo, 2008).

Currently, Nigeria, the eight most populous countries in the world, has begun grappling with issues of water scarcity across several its states forcing infrastructure and long-term sustainability questions. The water scarcity issue is considerably daunting, given the fact that Nigeria represents the eight most populous nations in the world – with a total population of over 152 million people. Among the 152 million who reside in Nigeria, less than 30 percent have access to adequate drinking water (Krebs, 2010). As earlier mentioned in this research, with renewable internal freshwater supply per capita of only 461 cubic meters (Gustaffson & Davies, 2015), Kenya faces absolute water scarcity, as defined by the United Nations threshold of renewable internal freshwater supply of 1,000 cubic metres per capita for absolute scarcity. The water services regulatory board (WASREB) (2009) established that there was water scarcity in the country and this increased domestic water use tariffs tremendously as compared to other east African states.

2.2.2. Trade waste effluent charges

To control excessive pollution of water bodies by industrial water users such as manufacturing firms, various legislations have been developed all over the world and amongst them is the trade waste effluent charges imposed on commercial water users dumping wastes containing toxic substances which are above the recommended levels into water bodies or sewerage systems. Therefore, due to the increasing costs required to meet tougher effluent discharge standards and to achieve pollution reductions, there is a growing shift towards the use of market-based instruments (MBI) such as emission taxes and emission trading, which can theoretically achieve the desired water quality standards at much lower cost (Kraemer, Kampa

& Interwies, 2003). The other familiar instruments include tax and subsidy approaches as well as traded property rights. All these instruments, try to internalize environmental costs.

Therefore, market-based instruments (MBIs) are regulations that encourage positive behaviour through market signals rather than through explicit directives regarding pollution control levels or methods. These policy instruments, such as tradable permits, trade waste effluent charges or pollution charges, are often described as "harnessing market forces" because if they are well designed and implemented, they encourage firms to undertake pollution control efforts that are in their own interests and that collectively meet policy goals (Stavins, 2003).

Colombia implemented a pilot program of water effluent charges after experiencing no success in pollution reduction with command and control regulations. Industrial polluters pay effluent fees based on the biological oxygen demand (BOD) and total suspended solids (TSS) (World Bank, 1999). Poland also developed a system of environmental/resource charges and fines as part of the environmental management system as early as in the 1970s, whereas pollution fees and environmental protection funds were first levied in the early 1980s (Kathura, 2012). Due to limitation on literature in South America, Mexico created a system of water effluent fees in 1991 to regulate BOD and TSS from municipal and industrial sources. However, most municipalities and a large proportion of industrial dischargers do not pay the fees (Seroa, Motta, Oseroaipeagovbrc, Bank & Nw, 1999). Penalties for non-compliance were established in 1997, but no research has shown whether enforcement has been sufficient to induce abatement, or payment of fees and penalties.

On the other hand, the Chinese 2002 Water Law, as amendment to the 1988 Water Law, provides a comprehensive framework for water resource management, with provisions encompassing: (1) water allocation, water abstraction and use rights, (2) river basin management, (3) water use efficiency and conservation, and (4) pollution prevention and resource protection (Cheng & Hu, 2012; Liu & Speed, 2009). However, Jiang, (2009) laments that China's water charge system is underdeveloped that is inadequate for managing water use and providing sufficient incentive for water saving and enhancing use efficiency. In theory, water use charge should be based on the volume of actual water use, with the price of water covering the full cost of per unit water supply, and thus guides water use in balance with supply by reflecting its full cost. Yet China's water prices are determined through a political top-down administration and are purposely set low, hardly covering the full cost of water supply. The user charges for urban water supply and wastewater treatment still do not fully cover all operating and capital costs. Implementation of water use charge is also subject to problems such as unclear responsibilities, low collection rates, and poor institutional capacities, requiring more attention to the institutional aspect of pricing policy (Zhong & Mol, 2010).

In Kenya, water use tariffs are low compared to other developing countries and compared to other tariffs such as energy. Due to this low rate, manufacturing industries often comply with payment of effluent and sewer charges for the connection to the sewerage system and for the services provided by the water company; however, non-compliance with the effluent water quality discharge regulations is what leads to high operation and maintenance costs of the sewerage treatment plants. Voluntary compliance initiatives such as voluntary compliance for cleaner production in Kenya, supported by the Kenya National Cleaner production centre have been implemented to promote compliance of these effluent water quality discharge regulations, however, there is not much literature written about the success of the initiative (Morara, 2013).

For this particular context, we look at NCWSC using trade waste effluent charges as an instrument to promote compliance and manage waste water. Trade waste effluent charges require that industries apply for a licence to be allowed to discharge their effluent to the sewer system. Before this licence is issued, the licensee is required to adhere to specific requirement such as installation of pre-treatment equipment in order to pre-treatment the effluent to make it meet the required water quality discharge standards. Once the quality meets the standards, the effluent can be discharged to the sewer system of NCWSC. To ensure that this is adhered to, the licence applicant should demonstrate that the effluent water quality has been meeting the standards for at least 6 consecutive months. Penalties are levied on those users who discharge effluent that does not meet the required standards and if non-compliance persists, the licence is cancelled, and the service withdrawn. For Nairobi Water and Sewerage Company, trade waste effluent charges, also called pollution charges are an important step towards the realization effective effluent management and promote investment in pollution prevention measures and eventually water security for industries. By levying a penalty on pollution, a clear signal is given that society is no longer willing to bear the costs of pollution and that at least part of the costs of the damage caused should be recovered directly from polluters (Roth, 2001).

2.2.3. Compliance of effluent water discharge regulations by manufacturing industries

Most countries have developed water quality regulations, but these rules vary in breadth, rigor, and enforcement (Claude, 2015). According to a research by Environmental Protection Agency (EPA) (2016) in Ireland established that 143 of 171 large urban areas complied with all the applicable effluent quality standards in the Urban Waste Water Treatment Directive. 51% of the national waste water load (by population equivalent) complied with the basic quality standards and just 25% of the national waste water load discharged into nutrient sensitive areas complied with the additional nutrient quality standards. This compares with EU compliance rates of 92% and 88% respectively. In other countries, industries have been using treated wastewater for cooling, boiler-feed, and process purposes since the early 1990s. The US states of California, Arizona, Texas, Florida, and Nevada have major industrial facilities using reclaimed water for cooling water and process/boiler-feed requirements (USEPA, 2004). Utility power plants are ideal facilities for reuse due to their large water requirements for cooling while petroleum refineries, chemical plants, and metal working facilities could use treated wastewater for their process needs.

In Africa, Oladepo, Ilori, and Taiwo, (2014) assessed the waste generation and management practices in Nigerian food industry and revealed that high cost of installing waste treatment plants (4.86 ± 0.069) ranked highest among the obstacles for the adoption of waste technology measures by food processing firms. A research by Mustapha (2013), in Kano, Nigeria's third largest city, most of the industries do not have wastewater treatment facilities and thus discharge their untreated effluents into the adjoining receiving water bodies. Adesogan (2013) discovered in his research that only Kaduna has a functional industrial wastewater treatment facility (Nigerian Brewery, Kaduna) in the northern part of Nigeria.

In Kenya, the National Environmental Management Authority (NEMA) is the body mandated with regulating and managing environmental pollution. NEMA has developed effluent water quality discharge regulations that outline the guidelines of the quality of water required to be discharged to the environment, sewerage systems and for re-use for agriculture or any other uses.

According to water quality regulations, 2006 environmental management and co-ordination (water quality) regulations, 2006, the regulations prohibit discharge of effluent into the environment that is contrary to the established standards. In the third schedule of the regulations, there are guidelines and standards of chemicals poisons, toxins, noxious, radioactive waste or other pollutants that can be released into the environment. The same regulations have standards for discharge of effluent into the sewer and aquatic environment. NEMA stipulates that it is the responsibility of the sewerage service providers such as NCWSC to regulate discharges into sewer lines based on the given specifications (OECD, 2013). For manufacturing industries to be able to comply with these regulations, it is important that they analyse the quality of the effluent water that is discharged from their processing plants or factories and compare this with the existing water quality discharge guidelines. If there are any parameters that are above the set standards, it is advisable for the industries to invest in installation of waste water treatment equipment. This equipment reduces the load of the contaminants to the admissible levels before discharge. In most instances, the quality of water is good enough for re-use within the factories or for other non-sensitive uses, however, typical case is that, industries fail to comply with these regulations and end up discharging the effluent without any kind of treatment. The current research assessed whether manufacturing industries are compliant with set regulations and the extent to which trade waste effluent charges have influenced the said compliance.

2.2.4. Effects of trade effluent charges on water security

Trade effluent charges have been introduced by various governments to help curb the disposal of toxic wastes into water bodies. In china, over the period 1995–2008, the total capacity of wastewater treatment facilities increased by almost 10 folds, but Yong, (2015) argued that the proportion of wastewater treated only increased by nearly 20–66%. In urban areas, wastewater treatment facilities often operate below capacity, do not operate at all, or are not well functioning with return flow meeting safe discharge standards (Zheng, 2012). In rural areas, only 1% of established villages and towns (about 25,000) have been equipped with wastewater treatment facilities, in contrast to the wastewater treatment penetration of nearly 82% in urban areas according to a report by Standard Chartered in 2014. As a result, a large amount of pollutants have been discharged into the environment, degrading the quality of receiving water bodies and aquatic ecosystems. These studies reveal compliance with some of the existing wastewater management regulations but do not indicate how trade waste effluent charges have influenced wastewater management by manufacturing firms in China or how the trade waste effluent charges have led to improvement of the capacity and efficiency of treatment plants which belong to water companies or municipalities.

In Colombia, it has been shown that trade effluent charges have resulted in decreased levels of toxic substance emission into water bodies indicating that the regulation has positive effects in controlling water pollution in the country (World Bank, 1999). According to Kathura, (2012), in Poland, the implication of the water charge shows a downward trend of wastewater discharge from 12,903 million m^3 in 1985 to 9797 million m^3 in 1994 revealing a fall of nearly 25%. The figures in this example are a compelling example of a country where the effluent charge has been successful. These studies in Colombia and Poland clearly shows that charges imposed on wastewater discharged by manufacturing firms can reduce the level of toxic substances found in wastewater dumped into water bodies by manufacturing firms. However, the studies need to be replicated in Kenya to find out if similar effects have taken place in Nairobi County Kenya.

In Nigeria, Oguzie, and Okhagbuzo, (2010) noted that metal concentrations were higher in the effluents. Total mean metal concentrations (mg/l) recorded in the effluents were Cd = 0.072; Cr = 0.079; Cu = 0.194; Ni = 0.122; Pb =0.125 and Zn = 0.174 while corresponding mean values recorded in the water were Cd = 0.043; Cr =0.072; Cu = 0.152; Ni = 0.091; Pb = 0.110 and Zn = 0.128. The concentrations of Cu, Pb and Zn in urban run-off effluents exceeded the limit recommended in effluent discharges to surface waters by the Federal Ministry of Environment (FMENV). Rim-Rukeh, and Agbozu, (2013) studied the impact of partially treated sewage effluent on the water quality of recipient Epie Creek Niger Delta, Nigeria using Malaysian Water Quality Index (WQI) and results showed that, the water quality across the sampling points was poor indicating that most parameters have deteriorated. In Kenya, penalties are imposed on industries disposing toxic wastes above recommended standards of toxicity into water bodies. However, no research had attempted to address how the existing effluent charges have affected water security in the County after the introduction of effluent charges an area covered by the current research.

2.2.5. Effect of trade effluent charges on operational performance of municipal waste water treatment plants

Trade effluent charges have a significant role to play in the operational performance of municipalities waste water treatment plants worldwide. In Europe, the implementation of the European Union's (EU's) Directive 91/271/EEC provided new rules for the discharge of sewerage and for its treatment, to avoid environmental pollution and damage to the ecosystems. The cost of energy consumed by waste water treatment plants can vary, ranging from 2% to 60% of total operating costs; thus, it can represent the main item of operating expenditures in a wastewater treatment plants (WWTP) (Carlson, & Walburger, 2007). The electrical energy consumption per m^3 of wastewater treated can vary, ranging from approximately 0.26–0.84 kWh/m^3 depending on several operational and environmental characteristics, such as pollutant loads, plant size and age, and type of WWTP (Venkatesh, & Brattebo, 2011). The average energy consumption for Germany, the United Kingdom, and United States is 0.67, 0.64, and 0.45 kWh/m^3, respectively, and for Italy, consumption between 0.40 and 0.70 kWh/m^3 was measured, depending on the type of plant (Cantwell, King, & Lorand, 2010).

In the United States for example, water and wastewater systems constitute 35% of a typical municipality's energy consumption (Copeland, 2014). Energy efficiency offers a means of cost reduction for utilities and municipalities and contributes to reducing energy demand. An increase of energy efficiency in wastewater treatment plants is possible by replacing plant components (such as pumps and air blowers) or by the complete re-engineering of the treatment process. Today, the promotion of energy efficiency, biogas or CHP happens in most industrialized countries, but the diffusion is slower in the developing world. In developing countries, municipalities simultaneously struggle with the provision of sanitation and stable electricity supply for their citizens. Farmers in water scarce areas tend to use untreated wastewater for irrigation (Amerasinghe, Bhardwaj, Scott, Jella, & Marshall, 2013). The rate of sewage collection in developing countries is low and the rate of wastewater treatment is even lower (upper middle-income countries 38%, low income countries 8%) (Sato, Qadir, Yamamoto, Endo, & Zahoor, 2013). In India, despite being an emerging economy, only 10% of all sewage generated is treated; 32% of urban households are connected to a piped sewer system (Sugam & Ghosh, 2013).

As reported by some authors, the higher consumption of electric energy is required by pumps (79%) to pump and treat wastewater (Singh, Deshbhratar, & Ramteke, 2012). The active sludge treatment, with the biological oxidation of pollutants, absorbs approximately 50% to 65% of the total consumption energy, in addition to the 11% required for the primary treatment, for grit, sand, and oil removal as well as sedimentation (Tchobanoglous, Burton, & Stensel, 2006). However, plant managers have the opportunity to significantly reduce energy costs through preliminary energy audits followed by process modifications. As described in Means, (2004), only an optimization of the aeration and pumping activities allows for annual savings ranging from 547 to 1057 million kWh, reducing the energy consumption by 6%.

In China, a research by Qinhong, Salma, Guangxin, Chunfeng, and Zhenjia, (2017) revealed that coal is the main energy resource in China hence pollution caused by coal gasification wastewater has been severe for decades. A three-stage system was adopted to treat the coal gasification waste water as anaerobic hydrolysis acidification (333 days), aerobic oxidation (300 days) and ozonation-aerobic fluidized bed process (220 days) with the lowest HRT of 45h. After, more than a year of trial high efficiency and stability of the treatment process has been achieved the results showed that when average influent (COD 4400 mg/L, total phenol 950 mg/L, volatile phenol 530 mg/L, NH4 +-N 300 mg/L, volatile acids120 mg/L and chromaticity 1000 times), the effluent COD could decrease to <60 mg/L, total phenol, volatile phenol, NH4 +-N, volatile acids were not detected, and chromaticity 10 times) showing average removal efficiency of COD, total phenol, volatile phenol, NH4 +-N and volatile acids of 96%, 99.9 %, 99.9%, 99.9% and 99.9%, respectively. The pollutants removed were conversed to biogas; organic transformation in the system was analyzed by GC/MS equipment. The power consumption and the amount of sewage sludge reduced 30%. The wastewater treatment cost is 0.135 $\$/m^3$. This research can be used to build a test to simulate future engineering applications of small scale technology platform as it is a short, simple processing unit, low energy consumption, low sludge production and easy management and maintenance.

On the other hand, Zhang, Yang, Ngo, Guo, Jin, Dzakpasu, Yang, Wang, Wang, and Ao (2017) reported and analyzed the current state of wastewater treatment plants (WWTPs) in urban China from the perspective of treatment technologies, pollutant removals, operating load and effluent discharge standards. By the end of 2013, 3508 WWTPs had been built in 31 provinces and cities in China with a total treatment capacity of 1.48 × 108 m^3/d. The technologies mostly used in WWTPs are AAO and oxidation ditch, which account for over 50% of the existing WWTPs. According to statistics, the efficiencies of COD and NH_3–N removal are good in 656 WWTPs in 70 cities. The overall average COD removal is over 88% with few regional differences. The average removal efficiency of NH_3–N is up to 80%. Large differences exist between the operating loads applied in different WWTPs. The average operating loading rate is approximately 83%, and 52% of WWTPs operate at loadings of b 80%, treating up to 40% of the wastewater generated. The implementation of discharge standards has been low. Approximately 28% of WWTPs that achieved the Grade I-A Discharge Standard of pollutants for Municipal Wastewater Treatment Plant (GB 18918–2002) were constructed after 2010. The sludge treatment and recycling rates are only 25%, and approximately 15% of wastewater is inefficiently treated. Approximately 60% of WWTPs have capacities of 1 × 104 m^3/d–5× 104 m^3/d. Relatively high energy consumption is required for small-scale processing, and the utilization rate of recycled wastewater is low. The challenges of WWTPs are discussed with the aim of developing rational criteria and appropriate technologies for water recycling. Suggestions regarding potential technical and administrative measures are provided.

Zhang, et al. (2017) further established that the operating loads of the 656 sewage treatment plants vary greatly, with an average operating load rate of approximately 83%. In general, the operating load of 52% of the WWTPs is b 80%, and the total treated water is 40%. The long-term low operating load increases the energy consumed in the treatment process. Additionally, only 30% of the WWTPs have operating loads of 80–100%, with nearly 40% of the wastewater being treated. The operating loads in 18% of the WWTPs exceed 100%, and 22% of the wastewater is overloaded. Moreover, the operating loads in 2% of the WWTPs are over 120%. Overloading of the operation affects wastewater treatment performance to a large extent, especially in terms of removing N and P and other pollutants. The overall operation loading rate in the seven regions varies considerably, of which the East, Central, and Southwest have the highest rates of over 85%.

In Italy, a research by Guerrini , Romano and Indipendenza (2017) studied energy efficiency drivers in wastewater treatment plants and the results showed that the variables with a significant influence on efficiency are the chemical oxygen demand concentration; plant capacity; rate of used capacity, which positively affects efficiency; weight of industrial customers, which exerts a negative impact; and aeration system, with a negative impact for turbines. Another research in India by Kaur, Wani, Singh, and Lal, (2012) showed that water, food and energy securities are emerging as increasingly important and vital issues for India and the world. Most of the river basins in India and elsewhere are closing or closed and experiencing moderate to severe water shortages, brought on by the simultaneous effects of agricultural growth, industrialization and urbanization. Current and future fresh water demand could be met by enhancing water use efficiency and demand management. Thus, wastewater/low quality water is emerging as potential source for demand management after essential treatment. An estimated 38354 million liters per day (MLD) sewage is generated in major cities of India, but the sewage treatment capacity is only of 11786 MLD. Similarly, only 60% of industrial waste water, mostly large-scale industries, is treated. Performance of state owned sewage treatment plants, for treating municipal waste water, and common effluent treatment plants, for treating effluent from small scale industries, is also not complying with prescribed standards.

In Canada, Omid, Yerushalmi, and Haghighat, (2015) established that Pulp-and-paper mills produce various types of contaminants and a significant amount of wastewater depending on the type of processes used in the plant. The research established that although both aerobic and anaerobic biological processes are appropriate for wastewater treatment, their combination known as hybrid processes showed a better contaminant removal capacity at higher efficiencies under optimized operating conditions with reduced GHG emission and energy costs. (Bryant,

2010) simulated the treatment process of pulp-and-paper wastewater in ASB and showed that although the treatment system could remove up to 67% COD from the wastewater, certain limitations such as nitrogen supply affected the removal efficiency of contaminants. (Schnell, Steel, Meker, Hodson, & Carey, 2000) compared three different laboratory-scale systems, namely AS, facultative stabilization basin (FSB) and ASB, in treating high rate and low rate Kraft mill wastewaters. Although the SRT in their experiments was quite long, the results showed that all three systems can remove up to 70% COD and 56% AOX from the wastewater.

Industries and other regulated private or commercial facilities such as hotels and hospitals in Nigeria are required by law to treat their wastewater to stipulated quality before discharge, but wastewater treatment before discharge or re-use by these facilities is usually inappropriately done or completely non-existent. Most industries in Nigeria lack efficient effluent treatment plants and therefore discharge their effluents into water bodies without adequate treatment, often into the nearest water bodies (Ipeaiyeda, & Onianwa, 2009). In Kenya, Otieno, Kumar, Onyango, and Ochieng (2014) studied treatment of tea industry wastewater using a combined adsorption and advanced oxidation process and revealed that the combined adsorption and advanced oxidation is most effective at pH 3 wherein the effluent colour was reduced from 478 Pt-Co colour units to 8 Pt-Co colour units. The latter meets the NEMA recommended limit for discharge of colored effluents.

A research by Ochoro, (2016) revealed that the onus and costs of managing waste streams should be placed on ‘producers’ of the waste and that, municipal solid waste management system has changed from being efficient to the current status that displays a lot of inefficiencies. It also showed that, storage, collection, transportation and final treatment/disposal of wastes has become a major problem in urban centers and that, the global trend of increased use of electrical and electronic goods has led to an increase in E-waste becoming a significant threat to our environment and human health. The current research assessed how the weight of industrial customers effluent discharge affects the operational performance of the waste water treatment plant at Nairobi City Water and Sewerage company. In as much as compliance of regulations may influence the operational performance of manufacturing firms, the current research is focusing on the effects of the effluent discharge standards and how these have affected the operational costs of the waste water treatment plants at Nairobi City Water and Sewerage company.

2.3. Theoretical literature review

In the next section, the researchlooks at the stakeholders' theory which aims to explain why it is important to look at the ethical requirements of a business to its stakeholders before looking at the business itself. The theory looks at organizational management and business ethics in a way to address morals and values and this links very closely with research as it explains how investors and business managers should look at sustainability especially for businesses like manufacturing industries whereby effective and efficient management of water and waste water is critical to their sustainability.

2.3.1. Stakeholders theory

This theory was propagated by Freeman (2010), which state that instead of starting with the business first then looking for what the ethical requirement is, the stakeholders theory will start looking at the world first before the business. According to the theory, it propagates that manufacturing and service companies should be socially responsible for all their stakeholders, failure to which, can result to the stakeholders to take actions and seek to find the legitimate claims and rights against the company actions. Stakeholder's theory affirms that those lives that are touched by the corporations hold a right and obligation to participate in directing the company. A simple example by Freeman (1984), when a factory produces industrial waste, an effluent charges perspective attaches a responsibility directly to factory owners to dispose the waste safely.

Stake holders' theory focuses on the stakeholders of the company, and in most cases this include the suppliers, employees, community, customers, shareholders and other person who contribute to the company directly or indirectly. Stakeholders of manufacturing companies want to see the company participate in effluent waste programs while shareholders of manufacturing companies would want the company to improve financially so that the waste management activities may continue to take place. Stakeholder theory implies that it can be beneficial for the manufacturing companies to engage in certain waste management activities that non-financial stakeholders perceive to be important, because, in the absence of this, these groups might withdraw their support for the firm hence affect the operational performance of the manufacturing companies (Donaldson and Preston, 1995).

This theory is important to evaluate in this research since it provides a useful argument that can be used by shareholders and stakeholders to compel industries to invest in environmental protection strategies such as effective waste water management solutions especially in cases where the command and control tools, regulations and financial and economic incentives do not exist. The theory emphasizes the need for manufacturing industries to invest in initiatives such as waste water treatment and recycling, reduction and optimization of water usage and rain water harvesting to protect the scarce resources and the environment at large. Such initiatives draw support from the shareholders as well as the stakeholders.

2.4. Conceptual framework

The research conceptualized that trade effluent charges herein referred to as the independent variable had the potential of influencing compliance of effluent discharge regulations and reducing water security risks also herein referred to as the dependent variables. Without the introduction of trade effluent charges, it is anticipated that there would been no compliance of effluent discharge regulations. This is because, water is undervalued and assumed to be a readily available resource. The low water tariffs experienced in the country also lead to a weak business case for manufacturing industries to invest in compliance of regulations for purposes of conservation of the resource.

Whether the trade effluent charges will lead to mitigation of water security risks depends on effect of the trade effluent charges. If the trade effluent charges have an effect on investment in water efficiency and waste water treatment and reuse, then there will be reduced pollution of water resources, leading to conservation of the water resources and this would ultimately reduce water security risks.

This relationship between the dependent and independent variables is shown in figure 1 below.

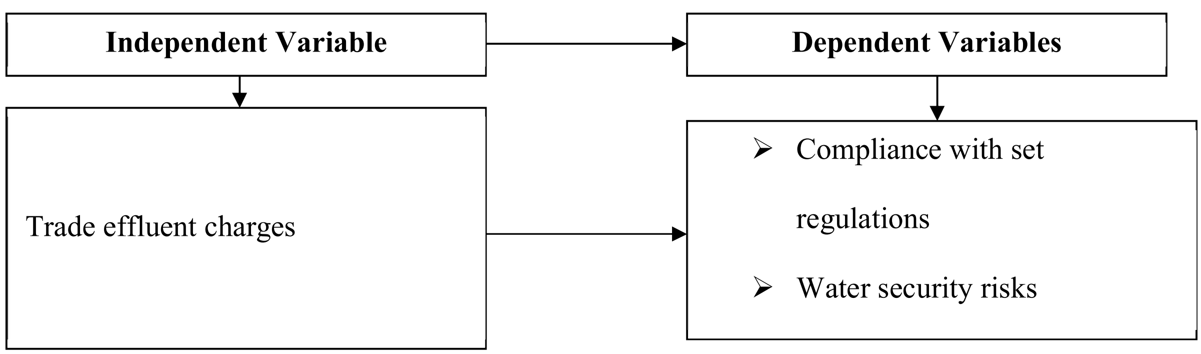


Figure 1: Conceptual Framework (Source; Researcher, 2018)

This is the conceptual framework that is going to guide my research going forward.

2.5. Conclusion/key issues

In the literature review, the research focused on the water security risks faced by manufacturing industries citing examples in China, South Africa and Nigeria. It also looked at the how trade waste effluent charges have been used to incentivize industries to invest in water conservation and pollution prevention to mitigate water security risks. It also reviewed compliance of regulations by manufacturing industries and effect of these trade waste effluent charges in water security risks and operational and maintenance costs of municipal treatment systems thereafter providing the relationship between trade effluent charges and water security risks and compliance of effluent discharge regulations. It concluded by a review of the stakeholders' theory.

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1. Introduction

In this chapter, the steps followed in undertaking the research are described. The research began with the research design, thereafter the research population follows, sampling techniques and sample size are described after that. In the subsequent section, the instruments used for the research are laid out as well as the pilot research. The validity and reliability of the instruments is then described, and the data collection and analysis procedures are presented in the section after before ending with ethical considerations.

3.2. Research design

This research adopted the descriptive survey research design research. In descriptive surveys studies are primarily concerned with determining "what is" (Mugenda & Mugenda, 2009). Surveys are exceptional tools for collecting first-hand data particularly in a large population and is useful for researching a specific phenomenon. Using this design, only a proportion of the large population was used to provide data required for the research. This research design was the most suitable as it enabled the researcher to gather data without making changes to any variables in the process. It also made it possible for the researcher to collect both qualitative and quantitative data using questionnaires and interview schedules.

Descriptive research design was selected as opposed to others such as exploratory or causal research designs. One research design under the exploratory research design is the experimental design technique whereby, participants are introduced to a controlled situation and thereafter observed with an expectation of change in behaviour which may occur because of the changed situation or manipulation. This research approach is not applicable in this case as the introduction of the regulation has already been done and the behaviour change is what is under observation. Whereas in the correlational research such as observational research where the participants are observed under a certain condition such as treatment. One group may be subjected to the treatment and the other is not. The change of behaviour of the samples is observed and this would not be applicable under this research as all participants are subjected to the water scarcity challenges and regulations and therefore subjecting some participants to the controlled environment would provide skewed findings.

3.3. Target population

The target population for this research was the 200 manufacturing industries as well as NCWSC in Nairobi county Kenya. The total target population therefore stood at 201. The choice of these groups was made based on the fact that they had more experience on the subject being studied.

3.4. Sampling technique and Sample size

3.4.1. Sampling technique

Two sampling techniques were used to gather the data needed from the respondents. These were simple random sampling technique and purposive sampling technique. The simple random sampling technique was used to select the operations managers of different manufacturing industries. The use of this technique enabled the researcher to give each potential respondent an equal chance to be chosen and participate in the research. According to Kelly et al, during the use of this technique, each individual respondent within the chosen population is selected by chance and is equally as likely to be picked as anyone else. (Kelley, Clark, Brown, & Sitzia, 2003). The technique also eliminated any form of bias in respondent selection during the process of data collection. Using these techniques, the researcher tore pieces of paper equal to the number of manufacturing industries in Nairobi, wrote numbers 1 to 20 in only 20 pieces living 180 pieces blank, folded, placed all of them in a basket, shook it and took the basket to the manufacturing industries. The researcher visited each industry and asked the operations managers to pick one piece of paper, and only those who picked a piece of paper with numbers written on them were issued with questionnaires. The process was repeated until all the needed 20 operations managers were selected. Kelly et al go ahead and mention in their journal that simple random sampling provides an estimate which is closer to the population than when the researcher uses a convenience sample of respondents who may have been in the right place at the right time (Kelley, Clark, Brown, & Sitzia, 2003). On the other hand, purposive sampling technique was used to select one participant from NCWSC for interview. This technique was used as only one respondent from the NCWSC was needed and therefore could easily be used.

3.4.2. Sample size

The population for this research comprised of the manufacturing industries personnel's in Nairobi County Kenya. From this population an adequate sample size was calculated to represent the population under investigation. Therefore, for this research an appropriate formula was used to calculate the required sample size from the target population. Sample size calculation formula proposed by (Naing, Winn, & Rusli, 2006) who argued that a good representative sample should constitute at least 20% of the entire population where a population is small and 10% where the population is large was used. The proposed sample size for the research was, therefore, computed as shown in Table 1.

Campus	Target Population	%age (%)	Sample size	Sampling Procedures
Operations managers	200	10.0	20	Simple random
NCWSC operations manager	1	100.0	1	Purposive
Total	**201**	**10**	**21**	

Table 1: Sample of the Research

Source: Author 2015

As shown in the table above, the research used a sample size of 31 participants, which made 10% of the total number of respondents in the target population.

3.5. Research instruments

In the following section, a description of the research instruments the following research used to collect information from the respondents is provided.

3.5.1. Operations managers' questionnaires

This instrument contained two sets of questions; close ended and open ended. This was suitable in gathering qualitative and quantitative data. The advantage of using open-ended questions, was that there were no pre-coded answers or response categories that were made available to the respondents. As for the closed ended questions, the research had to provide response categories and respondents had to select a specific answer. In Kelly's journal she mentions that closed questions with pre-coded responses are most suitable for topics where the possible responses are known such as in this case where the average range of water consumption or effluent discharge volumes could be estimated. She goes further to add that closed questions are quick to administer and can be easily coded and analyzed. As for the open questions, they can be more demanding but if well answered can provide useful insights into a topic. (Kelley, Clark, Brown, & Sitzia, 2003). The questions in the instruments addressed every objective of the research.

3.5.2. Structured interview schedule

This instrument was structured like the questionnaire and contained questions addressing every objective. The instrument was used to collect information from NCWSC operations manager through face to face interactions.

3.6. Pilot Research

Since this was the actual data collection component, a pilot research was done in a selected sample of manufacturing industries in Kiambu city, similar to the sample representing 10% of the manufacturing industries that participated in the actual research. This county was chosen because the demographic characteristics of individuals in it are similar to those of the target population. This enabled the researcher to make meaningful modifications to the research instruments. Piloting was helpful for it enhanced reliability and validity of the research instrument as a consistent measure of the concepts measured.

3.6.1. Reliability of the instruments

Reliability of an instrument is a measure of the degree to which it yields consistent results or data after repeated trial (Kothari, 2005). The researcher assessed the consistency of the responses on the pilot instruments to make a judgement on their reliability. Research instruments were evaluated for appropriateness of items to identify any errors. These errors were amended to ensure that the respondents clearly understood the questions. From the piloting results, reliability coefficient was determined using Pearson's Product Moment Correlation Method. A reliability coefficient value of $r>0.89$ was obtained which indicated a high internal reliability. According to Cohen (Cohen, 1988), correlation coefficients in the order of .10 are “small,” those of .30 are “medium,” and those of .50 are “large” in terms of magnitude of effect sizes.

3.6.2. Validity of the instruments

Content validity of the instruments was determined by expert judgments. The instruments were scrutinized by the project supervisors provided by the university to judge the items on their appropriateness of content and need of modification so as to achieve the objectives of the research. The supervisors determined whether the items in the research instruments adequately represented all the areas that needed to be investigated. In addition, the researcher also ensured validity of the data to be collected by administering the instruments personally as well as with the assistance of well-trained assistants.

3.7. Data collection technique

This process was undertaken in a week using data collectors with experience in data collection prior to this research. One field supervisor and the researcher were part of the field work. Three days training was provided to the data collectors and supervisors in Thika town where sampling of respondents and issuing of questionnaires by field assistants was practiced in actual field situation on 3 respondents by each data collector during the training. This was followed by discussions on the experiences gained from the practice. After the training, questionnaires were issued by field assistants to operations managers of manufacturing industries. On the other hand, a face to face interview was used to collect data from the NCWSC operations manager. The issued instruments were then collected after three days and prepared for data analysis.

3.8. Data analysis

The quantitative data collected in this research were analysed using descriptive statistics in the form of frequencies, percentages as well as inferential statistics in the form of linear regression analysis to test for the significance of relationship between the independent variable and the dependent variables. Scientific package for social sciences was used to aid in data analysis whereby after coding, the data was fed into this software in preparation for analysis where data was generated and presented in table and figures. Microsoft excel software version 12 was used to transform data from table format into figures. To test the hypotheses at 95% confidence level, liner regression models that follow were used;

$H0_1$: There was no significant relationship between trade effluent charges and water security in Nairobi County Kenya

$$Y=\beta_{0+}\ \beta_1X_1$$

Where

Y= Operational performance of manufacturing companies

$\beta_{0\,=}$ Intercept

$\beta_{1\,=}$ regression coefficients of independent variables

$X_{1\,=}$ Trade effluent charges

$H0_2$: There was no significant relationship between trade effluent charges and operational performance of manufacturing companies in Nairobi County Kenya

$$Y=\beta_{0+}\ \beta_2X_2$$

Where

Y= Water security risks posed by manufacturing companies

$\beta_{0\,=}$ Intercept

$\beta_{2=}$regression coefficients of independent variables

$X_{2\,=}$ Trade effluent charges

Both descriptive and inferential statistics were presented in tables and figures, however, for qualitative data, thematic analysis was used where themes were generated based on the research objectives and presented in a narrative form.

3.9. Research reliability and validity

The two main dependants of this research were compliance and water security risks. One way to measure whether manufacturing industries had been complying with the effluent regulations was by finding out their compliance with the trade waste effluent discharge regulations quality. For the other dependant, analysis of the water savings made by investments in compliance in regulations provides information on whether the trade effluent charges addressed water security risks.

From the literature review findings, China, Nigeria and Canada studies revealed that analysis of the operational performance of the municipal waste water treatment plants provides an indication of the compliance of dischargers with the trade waste effluent charges. To find out whether introduction of the trade waste effluent discharge charges had been beneficial to NCWSC, it was important to evaluate the effect that this charge had had on the operation and maintenance performance. The research chose to use the operation and maintenance performance to evaluate whether the introduction of the trade waste effluent charges was successful in addressing the challenge of discharge of polluted effluent into the municipal treatment plants of NCWSC. Since the main problem brought about by the discharge of contaminated effluent by manufacturing industries in Kenya was the high operation performance of the sewage treatment plant owned by the water company, one measure of the effectiveness of introduction of the trade waste effluent charge was measuring the operation performance of the treatment plant after the introduction of the charge and comparing this with the performance before the introduction of the charges.

The empirical literature review also found that most industries invested in water conservation due to the need to comply with regulations and not necessarily to mitigate water security risks and because of this second objective selected was to assess whether companies had made any savings in their water usage because of the introduction of the charge. The objective of introduction of the charge at the water company perspective was to promote compliance of effluent discharges to meet the set water quality regulations, however, several literature studies indicate that because of investing in compliance, water security is also achieved. This research measured the water savings or reused that arose because of the introduction of the charge by surveying a sample of 20 industries and assessed their water consumption before and after the introduction of the charge. It also assessed if there had been any investments made by the companies to comply with the regulations to avoid paying the charges. Once this information was obtained, it was assessed to find out whether the investment had led to water savings such as if the investment was made in waste water treatment and reuse, how much of the reused water had led to water savings.

CHAPTER FOUR

4. DATA ANALYSIS AND PRESENTATION OF FINDINGS

4.1. Introduction

The purpose of this research was to assess whether trade effluent charges could promote compliance and address water security risks in manufacturing industries in Nairobi County Kenya. This chapter therefore presents analyzed data in the form of descriptive statistics such as frequencies and percentages as well as inferential statistics in the form of chi-square test. These are presented using tables and figures. Results in this section are arranged as follows;

1. Compliance rates of manufacturing industries with effluent waste water discharge regulations
2. Water security risks faced by manufacturing industries
3. Effects of trade effluent charges on operational performance of Nairobi City Water and Sewerage Company
4. Effects of trade effluent charges on water security in Nairobi County Kenya

The groups for this research were 20 manufacturing industries operations managers in Nairobi County. Data was collected using structured questionnaires and interview schedule. To assess the relationship between the independent and dependent variables within each research objective at 95% confidence level, linear regression analysis was used. There was a 45% instrument return rate as only 9 instruments were returned dully filled.

4.2. Demographic characteristics of industries

The demographic characteristic collected from the respondents was the type of industry they worked for and the data collected is presented in table 1.

	Frequency	Percent
Food and Beverage (meats, dairy, water, juices, beers, spirits	6	66.7
Textile or garment manufacture	1	11.1
Oils and Refineries	1	11.1
Agro-processing	1	11.1
Total	**9**	**100.0**

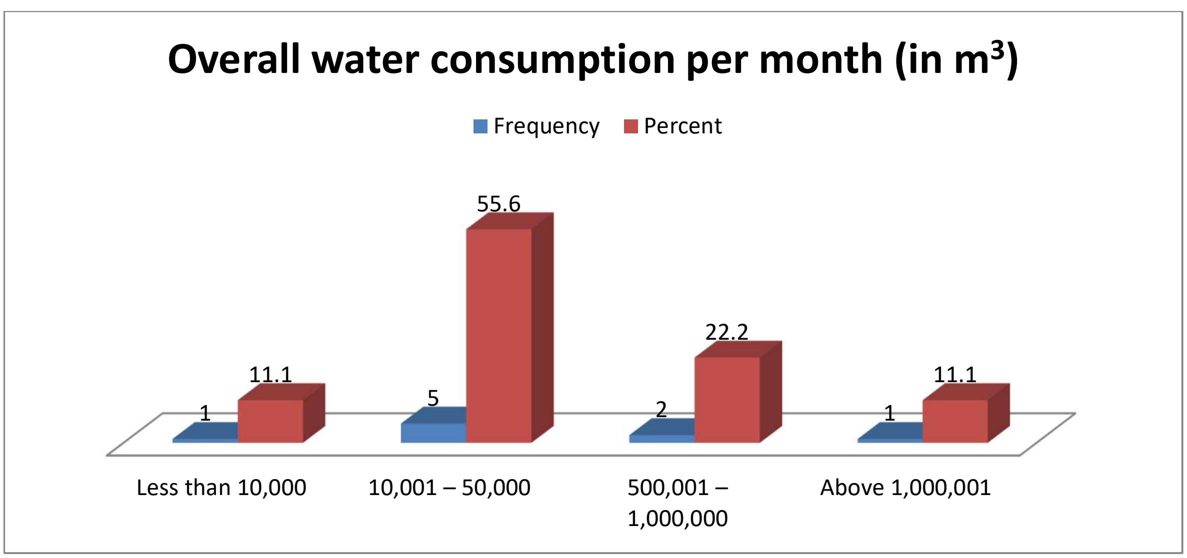
Table 1: Category of manufacturing

As results in table 1 show, most of industries that took part in this research were the food industries in Nairobi County Kenya as 66.7% of the operational managers indicated, 11.1% were textile/garment manufacturers, 11.1% were oil and refineries where as 11.1% were agro-processing industries. The findings of this research can be said to be more representative of the influence of trade effluent charge on compliance and water security within the food and beverage industries as opposed to other existing industries in Nairobi County Kenya.

4.3. Compliance of effluent discharge regulations

Information was also gathered on the overall water consumption of industries within Nairobi County Kenya and findings presented in figure 2.

Figure 2: Overall water consumption per month (in m^3)



Data gathered from the industries as presented in figure 2 reveal that in most industries in Nairobi County 55.6% consumed between 10,0001 to 50,000 m^3 of water on a weekly basis followed by 22.2% of the industries that consumed 500,0001-1,000,000 m^3 of water weekly, 11.1% consumed less than 10,000 m^3 of water whereas the remaining 11.1% consumed above 1,000,001 m^3 of water weekly. Based on this data, most industries consume about 10,001-50,000 m^3 of water in week in Nairobi County.

4.3.1. Industries awareness of the effluent discharge regulations

Operations managers were asked whether the industries were aware of effluent discharge regulations as stipulated in water quality regulations developed after the enacted National Environmental Management Act and their response is as presented in table 2.

	Frequency	**Percent**
Yes	9	100.0

Table 2: Industries aware of the effluent discharge regulations as stipulated in water quality regulations developed after the enactment of Environmental Management Act

Results as in table 2 above show that all industries 100% in Nairobi County were aware of effluent discharge regulations as stipulated in water quality regulations developed after the enacted National Environmental Management Act. This implies that there is awareness of effluent discharge regulations amongst industries discharging their effluents into the sewers of Nairobi County.

4.3.2. Compliance with NEMA effluent discharge regulations

Information was further collected from operations managers on compliance with the NEMA set effluent discharge regulations and results presented in table 3.

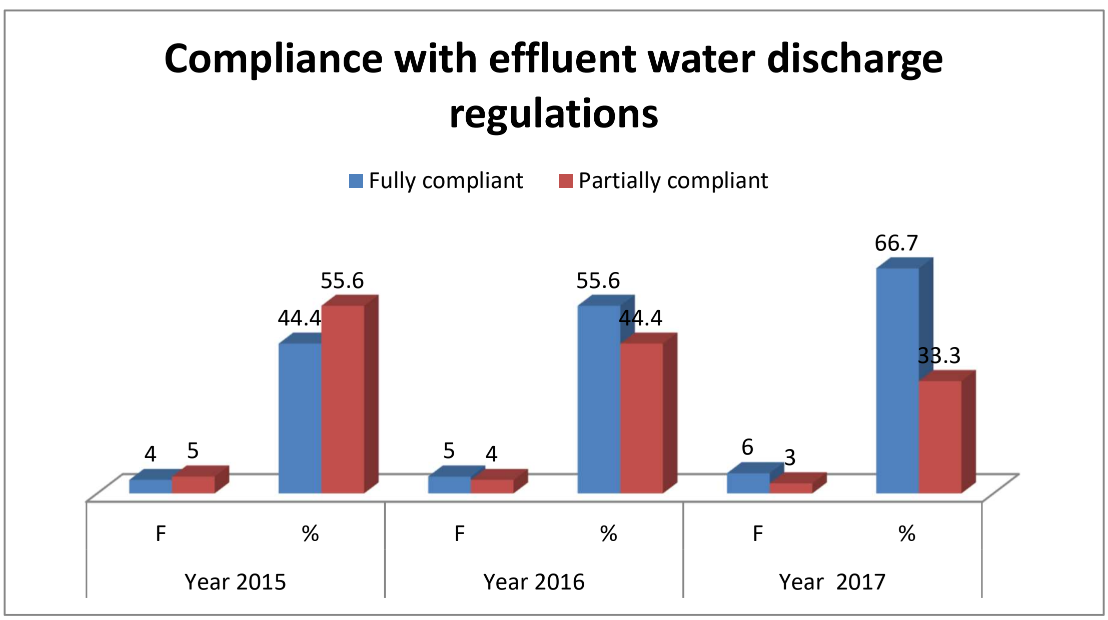
	Frequency	Percent
Yes	8	88.9
No	1	11.1
Total	**9**	**100.0**

Table 3: Compliance with NEMA effluent discharge regulations

The findings establish that out of the studied industries in Nairobi County, 88.9% were compliant with NEMA effluent discharge regulations where as 11.1% were not. This indicates that most of existing industries in Nairobi County Kenya were compliant with the established NEMA effluent discharge regulations.

The operations managers were further asked the extent to which industries were compliant with the set regulations and the data presented in figure 3.

Figure 3: Compliance with NEMA effluent discharge regulations



Results in figure 3 reveal that 55.6% of industries in Nairobi County were partially compliant with NEMA effluent discharge regulations in the year 2015, in 2016 however, a majority of

55.6% were fully compliant with the regulation while in 2017 a majority of 66.7% were fully compliant with the said regulation. These results imply that the level of compliance by NEMA effluent discharge regulations has been on the steady increase since the year 2015.

4.3.3. Availability of waste water treatment measures

The research also gathered information from operations managers on availability of waste water treatment measures in industries and findings are as in table 4.

	Frequency	**Percent**
Yes	8	88.9
No	1	11.1
Total	**9**	**100.0**

Table 4: Existing waste water treatment measures in industries

Most industries in Nairobi County were found to have waste water treatment measures as stated by 88.9% of the operations managers while only 11.1% of the industries lack such measures. This indicates that almost all manufacturing industries in Nairobi County have put in place waste water treatment measures and therefore do not dispose of effluent into the Nairobi sewers without pre-treatment.

4.3.4. Period of investment in waste water treatment measures

Additional information was sort on the period in which the said waste water treatment measures were installed and findings presented in table 5.

	Frequency	Percent
At inception	1	11.1
In 20 12	1	11.1
Over 10 years ago	7	77.8
Total	**9**	**100.0**

Table 5: When waste water treatment was initiated

The findings therefore showed that most of the manufacturing industries Nairobi County 77.8% installed waste water treatment measures over 10 years ago, 11.1% installed the measures in 2012 whereas 11.1% found this question not applicable to them as they lacked waste treatment measures as findings in table 5 indicate. Therefore, most manufacturing industries in Kenya have put in place waste water treatment measures to ensure their compliance with NEMA effluent discharge regulations.

4.4. Water security risks faced by manufacturing industries

More information was sort from the operations managers within manufacturing industries in Nairobi County Kenya on the average effluent water in m3 discharged in Nairobi sewers per annum and results presented in table 6.

	Year 2015		Year 2016		Year 2017	
	F	%	F	%	F	%
Less than 10,000	3	33.3	3	33.3	3	33.3
100,001 – 500,000	2	22.2	2	22.2	2	22.2
Above 1,000,001	4	44.4	4	44.4	4	44.4

Total	9	100.0	9	100.0	9	100.0

Table 6: Average effluent water discharged per annum (in m^3)

From the findings as presented in table 6, in the year 2015, 33.3% of the existing industries discharges on average less than 10,000 m^3 effluent water, 22.2% of the industries discharged on average between 100,0001-500,000 m^3 effluent water annually and the remaining 44.4% discharged over 1,000,001 m^3 effluents into Nairobi city sewers. These figures remained constant in all industries in the year 2016 and 2017 implying that most manufacturing industries in Nairobi County dispose an average of over 1,000,001 m^3 of water yearly into Nairobi city sewer systems.

4.4.1. Investment in effluent treatment or water reduction measures

The research also gathered data on whether manufacturing industries invested on effluent treatment measures or water use reduction measures and findings presented in table 7.

	Frequency	Percent
Yes	9	100.0

Table7: Number of industries with investments in effluent treatment or water reduction measures

From findings in table 7, the research established that all manufacturing industries have invested in effluent treatment measures as all the operations managers 100% mentioned. This finding therefore shows that most manufacturing industries in the studied County have invested in waste water reduction measures an act that improves their compliance with trade effluent charge regulations in Kenya.

According to information from operations managers, the effluent treatment measures invested in by manufacturing companies in Nairobi County are as shown in table 8.

	Frequency	Percent
Installed a PH correction plant and have a water team in place	2	22.2
Re-dying and flashing toilets, cleaning crates and compounds/social blocks	4	44.4
Establishment of a water team, installed a state-of the art water treatment plant, creation of a water map, performing daily water metering and monitoring, instituted a dry floor policy, launched a leak reduction program, fitted water horses with spray gun	2	22.2
Installation of a KSh 4.7 million Ultra Filtration (UF) that removes microorganisms and suspended solids from post-harvest water	1	11.1
Total	**9**	**100.0**

Table 8: Effluent treatment or water reduction measures in place

Findings in table 8 above reveal that most manufacturing industries in Nairobi County 44.4 have re-dye, flash toilets, clean crates and compounds as a water reduction measure, 22.2% installed a PH correction plant and had water teams in place, another 22.2% had established a water team, installed a state-of the art water treatment plant, created a water map, perform daily water metering and monitoring, instituted a dry floor policy, launched a leak reduction program and fitted water horses with spray gun as water reduction measure while the remaining 11.1% installed a Ksh 4.7 million Ultra Filtration (UF) that removes microorganisms and suspended solids from post-harvest water as water treatment measure. The results show that a majority recycle waste water and that some companies have similar measures for water treatment in Nairobi County Kenya.

Information was further collected from operations managers on cost incurred while investing on the said effluent treatment measures and findings presented in table 9.

	Frequency	**Percent**
100,001 – 500,000	3	33.3
5,000,001 – 10,000,000	1	11.1
Above 10,000,001	4	44.4
None	1	11.1
Total	**9**	**100.0**

Table 9: Investment cost incurred in the effluent treatment measures

On the investment cost incurred in waste water treatment measures, most industries 44.4% spent over 10,000,001 KShs in waste water treatment investment, 33.3% spent 100,001-500,000 KShs in such investment while 11.1% incurred a cost of 5,000,001-10,000,000 Kshs while investing in waste water treatment measures in Nairobi County. This imply that the cost of operations of most industries in Nairobi County has gone up as a result of investment in waste water treatment in compliance with NEMA effluent discharge regulations in Kenya.

Information was further sought from respondents on whether the industries reused and or recycled the treated effluent water and data presented in table 10.

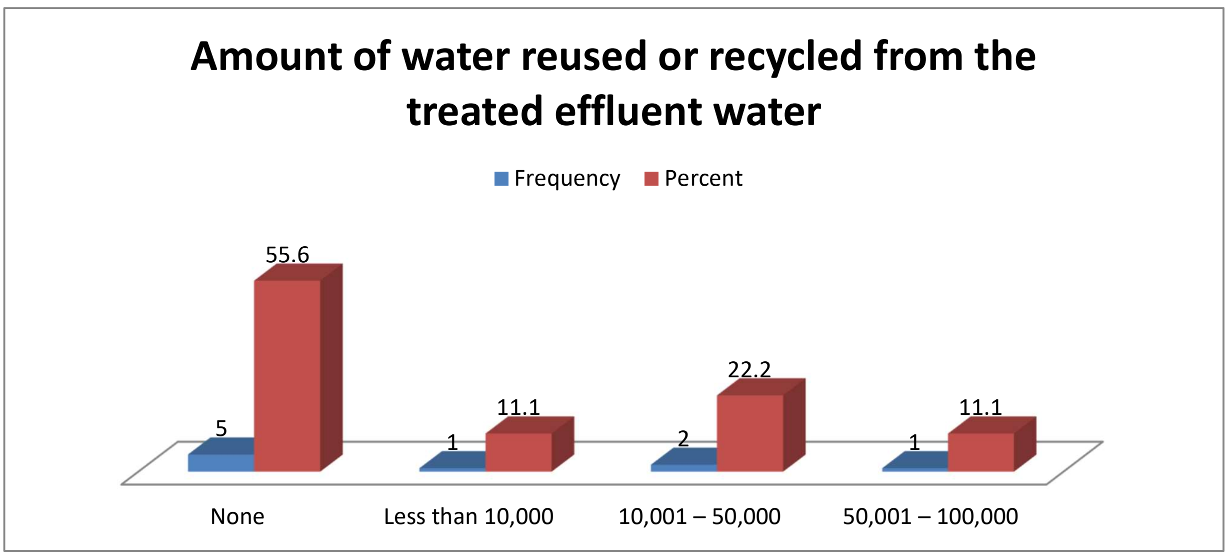
	Frequency	**Percent**
Yes	4	44.4
No	5	55.6
Total	**9**	**100.0**

Table 10: Reuse or recycling of treated effluent water

From the findings, most industries in Nairobi County do not reuse the treated water as a slight majority of operations managers 55.6% observed while only 44.4% of existing industries within the County recycle the treated effluent water. This means that a slight majority of industries in the research area do not make use of the waste water they have treated and thereby missing an opportunity to reduce the operational costs arising from water consumptions while could have been reduced if the treated water was used in one way or another by the industries.

Information was further sought from operations managers on the amount of treated effluent water recycled by the industry and the results presented in figure 4.

Figure 4: Amount of water reused or recycled from the treated effluent water



Of the industries that recycled their treated waste water in Nairobi County, a majority of 22.2% reused 10,001-50,000 m^3 of recycled water, 11.1% reused less than 10,000 m^3 of the treated effluent water whereas the remaining 11.1% reused 50,001-100,000 m^3 of recycled water as results in figure 4 show. This shows a partial reuse of treated water by industries in Nairobi where a majority generate more than 1,000,000 m^3 of waste water per year. This implies that these industries are not fully utilizing the treated water for other purposes despite its potential of reducing their costs of operations. However, it shows a slight reduction in amount of water consumed by these industries annually and therefore implying that the effluents discharged into Nairobi County sewers have significantly reduced.

More specific information was gathered quantitatively on whether the amount of water used for manufacturing processes by the industries and results presented in table 11.

	Frequency	**Percent**
Yes	9	100.0

Table 11: Reduction in the amount of water used for manufacturing purposes

The research results as in the above table show that all the industries including those that do not reuse treated waste water have experienced a reduction in the amount of water used for manufacturing purposes as all the operations managers 100% mentioned. This indicates that the industries are no longer consuming the same amount they used to before and therefore are putting less strain on the existing usable water resources in Nairobi County. These findings provide a stronger argument that justifies the need for industries to apply the stakeholders theory. The shareholders and stakeholders can easily withdraw when they realise that despite the positive benefits of investing in effective waste management measures such as treatment and reuse of waste water, if the industries are not do not making use of this opportunities.

The research was also interested on the volume of water reduction in m^3 on a yearly basis in years of 2015, 2016 and 2017 and findings based on the gathered data are as presented in table 12.

Volume in m^3	**Year 2015**		**Year 2016**		**Year 2017**	
	F	**%**	**F**	**%**	**F**	**%**
None	2	22.2	2	22.2	3	33.3
Less than 10,000	2	22.2	2	22.2	2	22.2

10,001 – 50,000	2	22.2	2	22.2	1	11.1
50,001 – 100,000	2	22.2	1	11.1	1	11.1
100,001-500,000	0	0.00	1	11.1	1	11.1
Above 1,000,001	1	11.1	1	11.1	1	11.1
Total	**9**	**100.0**	**9**	**100.0**	**9**	**100.0**

Table 12: Estimated volume of water use reduction (in m^3) experienced

In the year 2015, 22.2% of the industries experienced on reductions, 22.2% experienced less than 10,000 m3 water use reduction, 22.2% experienced 10,001-50,000 m^3 reduction and another 22.2% had 50,001-100,000 m^3 reduction in the same year. In 2016, 22.2% of industries experienced no reduction in water use whereas in 2017 33.3% experienced no water use. These amore findings are as shown in table 12 above. The findings therefore imply that there is slight reduction in water usage by manufacturing industries in Nairobi County however, some of the existing industries have significantly reduced their municipal water usage on a yearly basis.

4.5. Effects of trade effluent charges on operational performance of NCWSC

Data was collected from respondents on the effect of NEMA effluent discharge regulations on operational performance of manufacturing industries and findings presented in table 13.

	Frequency	Percent
No effect as the cost has always been part of the budget	4	44.4
Low production	1	11.1
Increased ETP running cost	2	22.2
Budget for water treatment system and water discharge mass balance to effectively monitor water quality before discharging to the sewage	1	11.1
Effluent discharge regulations have led to investment in post-harvest water treatment equipment that led to reuse the effluent water, thereby reducing operational costs by KShs 120,000 per month	1	11.1
Total	**9**	**100.0**

Table 13: Effect of effluent discharge regulations on operational performance of manufacturing industries

As the findings in table 13 show, in most industries in Nairobi County 44.4%, NEMA effluent discharge regulations has had no effect on their operational performance as the cost of effluent discharge has always been part of their budget, 11.1% of the industries have experienced reduced production while 11.1% has experienced a rise in ETP running costs as operations managers mentioned. These and additional results are as presented in table 13. The findings therefore imply that for industries that had invested in effluent discharge at inception, their operational performance in terms of energy consumption, water usage, chemical purchases among others have not gone up as a result of the regulations whereas industries that did not have water treatment measures at inceptions have experienced an increase in their operational costs in one way or another in Nairobi County Kenya.

More information was gathered from the manufacturing industries operations managers on the effect of NEMA effluent discharge regulation on water use by industries and results presented in table 14.

	Frequency	**Percent**
No effect	4	44.4
Reduced water usage 15m3/day resulting in savings because of water reuse	5	55.6
Total	**9**	**100.0**

Table 14: Effect of effluent discharge regulations on water use by industries

Results presented in the above table reveal that most of the industries 55.6% in Nairobi County experienced reduced water usage whereas the remaining 44.4% of the industries had had no effect on their water usage as a result of the enactment of NEMA effluent discharge regulations. From these findings, there is a general reduction of water inputs by manufacturing industries in Nairobi County Kenya which results in reduced effluent load generation and discharge into Nairobi sewers as well.

A linear regression analysis was carried out to test for the relationship between the dependent variable of operational performance and independent variable of NEMA effluent charges at 95% confidence level. The hypothesis and regression model were as follows;

$H0_1$: There is no significant relationship between trade effluent charges and water security in Nairobi County Kenya

$$Y=\beta_{0+}\ \beta_1 X_1$$

Where β_0 is the regression intercept, β1 the regression coefficient. Y is the dependent variable of water security risk while X_1 is between trade effluent charges.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.818[a]	.669	.667	.450

Table 15: Model Summary of the relationship between effluent charges and operational performance of NCWCS

In table 15, the results presented indicate that in research area trade effluent charges are significantly related to operational performance of NCWCS by 67% as the coefficient of determination R^2 if 66.9. Therefore, other variables not studied affect operational performance of NCWCS in the Nairobi County by 33.1%. This indicates that trade effluent charges affects operational performance of NCWCS 67% in Nairobi County Kenya.

Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	61.138	1	61.138	301.511	.000[a]
Residual	30.213	149	.203		
Total	91.351	150			

Table 16: Analysis of variance on the relationship between effluent charges and operational performance of NCWCS

The analysis of results presented in table 16 established that there exists significant relationship between the independent variables (trade effluent charges) and the dependent variable (operational performance of NCWCS) with a p-value of 0.000 which is lower than p=0.05. The F calculated value for the research at 95% confidence level is 301.511 also indicating a statistical significant relationship between the dependent and independent variables studied.

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	0.115	0.163		0.707	0.481
NEMA effluent charges	0.870	0.050	0.818	17.364	0.000

Table 17: Coefficients Model of the relationship between effluent charges and operational performance of NCWCS

a. Dependent Variable: Operational Performance of NCWCS

In table 17, the established regression equation was Y= 0.115 + 0.707X1, which showed that holding other factors constant at 0, trade effluent charges in the studied manufacturing industries affect operational performance of NCWCS significantly. The research therefore reveals a significant relationship between trade effluent charges and operational performance of NCWCS in the research area with a p-value of 0.000. This also proves that there is a significant relationship between the two investigated variables investigated.

4.6. Effects of trade effluent charges on water security in Nairobi County Kenya

Manufacturing companies rely heavily on water and therefore information was gathered on the effect of NEMA effluent discharge regulations on the industries water security and findings presented in table 15.

	Frequency	Percent
No because we have always used boreholes and other water harvesting measures	5	55.6
Yes it has increased the industries water security by encouraging industries to recycle water, invest in rain water harvesting and borehole water	4	44.4
Total	**9**	**100.0**

Table 18: Effect of NEMA effluent discharge regulations on manufacturing industries water security

On the effects of NEMA effluent discharge regulations on manufacturing industries water security, most manufacturing industries in Nairobi County Kenya 55.6% of the operations managers mentioned that the regulation had in no way affected their industries water security as they had always used boreholes and other water harvesting measures before the regulations were enacted while 44.4% said that the regulation had increased their water security by encouraging them to recycle water, invest in rain water harvesting and also utilize borehole water as findings in table 18 indicates.

The researcher also sought information from operations managers on aspects of water security normally affected by the established NEMA effluent discharge regulations and findings are as presented in table 19.

	Frequency	Percent
Not applicable	5	55.6
The NEMA regulation prohibits borehole use affecting water security by company negatively	1	11.1
Clean water discharged by our company into the rivers is used by farmers downstream. Therefore reducing water demand	2	22.2
There is reduced reliance on supplied piped water and ground water, thereby mitigating any climate change risks that may affect water supply to the organization. With rain water harvesting, the company has secured an alternative source of water.	1	11.1
Total	**9**	**100.0**

Table 19: Aspect of water security affected by NEMA effluent discharge regulations

The research findings established that 22.2% of the respondents observed that discharged treated water was used by farmers downstream and therefore reducing water demand, 11.1% mentioned that the regulation prohibits borehole use which negatively affects the industries water security while 11.1% mentioned that the regulations has led to reduced reliance on piped water and also increased rain water harvesting which has increased water security in their industries. These findings are as presented in table 19 above.

The researcher used linear regression analysis to test for the relationship between the dependent variable of water security risks and independent variable of NEMA effluent charges at 95% confidence level. The hypothesis and regression model were as follows;

$H0_2$: There is no significant relationship between trade effluent charges and operational performance of manufacturing companies in Nairobi County Kenya;

$$Y=\beta_{0+}\ \beta_2X_2$$

Where β_0 is the regression intercept, β_2 the regression coefficient. Y is the dependent variable of water security risk while X2 is between trade effluent charges.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.926[a]	.857	.856	.296

Table 20: Model Summary of the relationship between trade effluent charges and water security

a. Predictors: (Constant), trade effluent charges

In table 16, the results presented indicate that in research area trade effluent charges are significantly related to water security risks by 86% as the coefficient of determination R^2 if 85.7. Therefore, other variables not studied affect water security risks in the studied area by 24%. This indicates that trade effluent charges affects water security risk 84%.

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	78.317	1	78.317	895.277	.000[a]
	Residual	13.034	149	.087		
	Total	91.351	150			

Table 21: Analysis of variance of the relationship between trade effluent charges and water security

ANOVA results presented in table 20 reveal that there exists significant relationship between the independent variables (trade effluent charges) and the dependent variable (water security risks) with a p-value of 0.000 which is lower than p=0.05. The F calculated value for the research at 95% confidence level is 895.277 also indicating a statistical significant relationship between the dependent and independent variables investigated.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.319	.109		-2.923	.004
	NEMA effluent charges	.810	.027	.926	29.921	.000
a. Dependent Variable: Performance of water security						

Table 22: Regression coefficients of the relationship between trade effluent charges and water security

In table 21, the established regression equation was $Y= -0.319 + -2.923X_2$, which showed that holding other factors constant at 0, trade effluent charges in the studied manufacturing industries is significant at p=0.004. The research therefore reveals a significant relationship between trade effluent charges and water security risks in the research area with a p-value of 0.004. This also proves that there is a significant relationship between the two investigated variables investigated.

4.7. Summary

4.7.1. Compliance of manufacturing industries with effluent discharge regulations

Data gathered from the industries as presented reveals that most industries in Nairobi County consume between 10,001 to 50,000 m^3 of water on a weekly basis followed by those that consume 500,0001-1,000,000 m^3 of water weekly, ones that consume less than 10,000 m^3 of water whereas ones that consume over 1,000,001 m^3 of water weekly are fewer. On the other hand, all manufacturing industries in Nairobi County were found to be aware of effluent discharge regulations as stipulated in water quality regulations developed after the enacted National Environmental Management Act. Further, a majority of the manufacturing industries in Nairobi County, are compliant with NEMA effluent discharge regulations. The research further showed that compliance with the set regulations have been on a steady increase from the year 2015 to 2017. The results further established that waste water treatment measures were available within almost all manufacturing companies in Nairobi County Kenya and majority of the manufacturing industries in the installed such measures over 10 years ago.

4.7.2. Water security risks faced by manufacturing industries

Information on water security risks revealed that from 2015 to 2017, manufacturing industries in Nairobi County have been mostly discharging a varying amount of effluents into the sewers of Nairobi city. The figures vary from one company to the next by year and range from under 10,000 m^3 to over 1,000,001 m^3 yearly. The research also established that all manufacturing industries have invested in effluent treatment measures. The effluent treatment measures used by these companies were found to include re-dying, flashing toilets, cleaning crates and company compounds, installing a PH correction plant, having water teams in place, installing a state-of the art water treatment plant among other measures. These measures were however costly as most companies spent between 100,000 to 10,000,000 Kshs in waste water treatment investment. However, after treating effluent discharge, only 44.4% of the manufacturing industries reuse the treated water for other activities. The research further reveals that after recycling of waste water, all the manufacturing industries including those that do not reuse treated waste water experienced a reduction in the amount of water used for manufacturing purposes with reduced amount varying from one company to the next each year.

4.7.3. Effects of trade effluent charges on operational performance of NCWSC

The research results further established that in most industries in Nairobi County, NEMA effluent discharge regulations has had no effect on their operational performance as the cost of effluent discharge has always been part of their budget, while other industries have experienced reduced production and the rest experienced a rise in ETP running costs. NEMA effluent discharge regulations have resulted in reduced water usage by a slight majority of manufacturing industries in the research area.

4.7.4. Effects of trade effluent charges on water security in Nairobi County Kenya

Lastly, on the effects of NEMA effluent discharge regulations on manufacturing industries water security, in most manufacturing industries in Nairobi County Kenya, the regulation had in no way affected their water security as they had always used boreholes and other water harvesting measures before the regulations were enacted while the in the remaining few, the said regulations had increased their water security by encouraging them to recycle water, invest in rain water harvesting and also utilize borehole water. The research further established that discharged treated water was used by farmers downstream and therefore reducing water demand, the regulation prohibits borehole use which negatively affects the industries water security and that the regulations has led to reduced reliance on piped water and also increased rain water harvesting which has increased water security in their industries.

In conclusion, the data collection and analysis were successful and provided useful insights in establishing the average water consumption rates for manufacturing industries in Nairobi and their level of compliance. It also exhibited the level of awareness that manufacturing industries have in the effluent discharge regulations and the effects that the trade effluent discharge regulations have had on investment for water security.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

In this chapter, the research presents the conclusions arrived at by the researcher based on the findings, the literature review and the analysis. After the conclusions, the researcher then presents limitations of the research and thereafter breakdown the recommendation into two main sections; one focusing on corporate managerial recommendations and the other one focuses on policy recommendations.

5.2. Conclusion

The purpose of this research was to assess whether trade effluent charges can promote compliance and address water security risks in manufacturing industries in Nairobi County Kenya. Based on the research results, the research concludes that with respect to the compliance rates of manufacturing industries with effluent waste water discharge regulations, there is both partial and full compliance with effluent discharge regulations as some companies discharge partially contaminated effluent into the sewer systems while others have put in measures to pre-treat their effluent before discharge.

On water security risks faced by manufacturing industries, the amount of effluents discharged into the sewers by the industries is still high even though the manufacturing industries have invested in effluent treatment measures and the amount of treated water being reused by the industries is low compared to the actual treated waste water discharged in sewers and the environment. Most industries cited that the pre-treatment measures are costly as most companies spent between KES 100,000 to 10,000,000 in waste water treatment investment.

The research also concludes that after recycling of waste water, the manufacturing industries experienced a reduction in the amount of water used for manufacturing purposes. The research also concludes that the regulations have not compelled all industries in Nairobi County Kenya to invest in measures to avert water security risks since the industries invested in boreholes and other water harvesting measures to avert this risk before the regulations were enacted, however for some, the regulations have led to increased water security by encouraging investment in treatment of the waste water leading to reuse of that water for other purposes such as irrigation by farmers downstream therefore reducing reliance on piped water and increasing investment in rain water harvesting.

From the literature review, In Colombia, it has been shown that trade effluent charges have resulted in decreased levels of toxic substance emission into water bodies indicating that the regulation has positive effects in controlling water pollution in the country (World Bank, 1999). According to Kathura, (2012), in Poland, the implication of the water charge shows a downward trend of wastewater discharge from 12,903 million m^3 in 1985 to 9797 million m^3 in 1994 revealing a fall of nearly 25%. The figures in this example are a compelling example of a country where the effluent charge has been successful. However, in Kenya, the research has found that not all industries have been able to comply with discharge regulations and therefore some still release effluent that is contaminated. Only 44% of the industries are reusing their waste water treatment, showing that there is an opportunity to increase waste water reuse by either introducing incentives or market-based instruments. This is because water is undervalued in Kenya and there is no strong business case to compel industries to invest in waste water treatment and re-use. The cost of investment in some industries is higher than the operational savings that the investment brings. This is also because industries only consider cost of water as the tariffs paid at the end of the month rather than full costs of water such as pumping, treatment, cost of compliance and energy costs incurred.

The research results further conclude that for most industries, NEMA effluent discharge regulations has had no effect on their operational performance as the cost of effluent discharge has always been part of their budget, while other industries have experienced reduced production while others experienced a rise in ETP running costs. The regulations have also resulted in reduced water usage by a slight majority the industries.

Considering that the regulations have not been fully effective in compelling industries to invest in waste water treatment and reuse and reduction of water usage to avert water security risks, the stakeholders' theory is very applicable in this context as another way of promoting investment in effective waste water management. The stakeholders such as the suppliers, employees, community, customers and shareholders need to hold the manufacturing industries accountable for their activities and ensure that they include in their strategies initiatives to invest in effective waste water management.

5.3. Limitations of the research

This research would have taken into consideration other constraints that would also affect the lack of compliance by industries such as price of water and lack of locally available abatement solutions but due to time constraints, the research will be limited to use of data on cost of operations and maintenance as well as pilot industries that have invested in abatement solutions and the resultant water savings to determine the success of the introduction of the trade effluent charges.

Additionally, it would have been useful to also consider the influence that the other regulations such as the NEMA effluent discharge penalties and EMCA act towards contribution to promoting compliance within the manufacturing industries and whether this has supported the promotion of compliance but there isn't sufficient data on effluent treatment investment nor water usage reduction because of these two regulations.

The researcher was not able to collect all the data from the sample size selected. Out of the target of 20 manufacturing industries, only nine were able to fill the questionnaire and send back the information to the researcher. Most of the industries argued that this is sensitive information and despite the researcher providing an ethics form and letter from the University, the industries were hesitant to divulge information about their water use, compliance of regulations and investment in waste water management. This is largely attributed to the fact that most industries are reluctant to share this data due to non-compliance and misuse of the water resources on their part. In some cases, the approval to share the information had to be provided my directors or managers who were not in the country at the time of data collection, despite several efforts to reach them at different times.

5.4. Recommendations

From the findings and conclusions above, the researcher had the following policy and corporate recommendation to make to the manufacturing industries, Nairobi water and Sewerage Company and the National Environmental Regulator

5.4.1. Corporate/Managerial recommendations:

5.4.1.1. Manufacturing industries:

The researcher recommends that there is a need to ensure that there is full compliance with NEMA effluent discharge regulations by all manufacturing industries. Further, better strategies for effluent treatment need to be established by the manufacturing industries and may include collaboration and establishing a joint effluent treatment plant to reduce the cost of individual effluent treatment. The researcher adds that companies invest in state of the art water harvesting technologies. This will help both the industries and NCWCS be able to guarantee water security to their targets.

The researcher also recommends that the manufacturing industries should consider use of the stakeholder's theory when designing their investment strategies. The industries should incorporate in their investment strategies, budget for environmental protection such as investments that reduce pollution of water bodies and reducing water footprint or water usage. By doing this, their shareholders will see value in the investment and in return will contribute to the water security risk mitigation.

5.4.1.2. Nairobi City Water and Sewerage Company

The researcher recommends that to reduce the operational cost incurred by the NCWCS, regulations such as polluter pays principle or incentives must be introduced to ensure that companies pay for all the additional costs incurred by NCWCS as a result of their disposal of effluents that are way above the standards.

5.4.2. Policy recommendations;

To avert water security risks, the researcher also recommends that the national environmental regulator, NEMA must ensure that industries reuse most of its treated water rather than discharging it into the sewers.

In order to ensure that companies comply and discharge effluent that meets the required quality, since the regulations are not enough, it is important that the regulator, together with the municipal companies such as NCWSC introduce pollution taxes or tariffs such as the polluter pays principle to ensure that polluters pay for the pollution load and additional costs incurred by NCWSC.

The researcher also recommends that to encourage rain water harvesting, the national regulator, NEMA should lift any restrictions imposed on industries' use of alternative sources of water harvesting.

5.5. Avenues for future work;

There are opportunities to strengthen this research or increase the scope of the research to look at a national level rather than one county as there are many other issues in the other counties that could strengthen the argument for policy recommendations.

Given the limitations on the data collection, additional studies done with larger sample sizes or additional data from a wider variety of manufacturing industries might provide more insights into the conclusions made.

It would also be useful if more studies were done comparing the effect of other regulatory instruments or command and control tools that are there to provide comparison between those other tools and the effluent discharge regulations.

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7. APPENDICES

7.1. APPENDIX I: SURVEY QUESTIONNAIRE MANUFACTURING INDUSTRIES

Purpose

The purpose of this survey is to establish whether the introduction of NEMA effluent water quality regulations has led to compliance of effluent water quality discharged by manufacturing industries. With increased population and urbanization, there has been a gap in supply and demand of water supply, the survey also aims to collect information about the water security risks faced by manufacturing industries because of this.

In sharing the volume of effluent water discharged by industries before and after the introduction of the water quality regulations in Nairobi, the survey will be able to establish whether there have been savings in water discharged. The questionnaire also seeks to find out if there have been any investments made in waste water treatment plants to treat and reducing the amount of effluent that is discharged to the sewerage system and whether these investments has led to any water savings as a way to address the water security risks.

The information you will provide by filling out this questionnaire will be used anonymously for academic purpose only and strictly remain confidential.

Instruction

This survey has 18 questions and will take approximately 15 minutes to complete.

Section A: Demographic Data

1. Which category of manufacturing does your industry fall under?

☐Food and Beverage (meats, dairy, water, juices, beers and spirits)

☐ Textile or garment manufacture

☐ Chemicals (Pharmaceuticals, Fertilizers, Industrial chemicals)

☐ Sugar or confectionery

☐ Oils and Refineries

☐ Cement

☐ Wood manufacturing

☐Paper and pulp

☐Steel manufacturing

☐other, please specify ___________________________________

2. What is your overall water consumption per month (in m^3)

☐ less than 10,000

☐ 10,001 – 50,000

☐ 50,001 – 100,000

☐100,001 – 500,000

☐500,001 – 1,000,000

☐Above 1,000,001

3. Are you aware of the effluent discharge regulations as stipulated in Water Quality regulations developed after the enacted National Environmental Management Act?

☐ Yes ☐ No

4. Does your effluent water comply with the above set regulations?

☐ Yes ☐ No

5. How would you rate the compliance of the effluent water discharge regulations over the last three years?

2015	2016	2017
☐ Fully compliant	☐ Fully compliant	☐ Fully compliant
☐Partially compliant	☐ Partially compliant	☐ Partially compliant
☐ Does not compliant	☐ Does not compliant	☐ Does not compliant

6. Do you have a waste water treatment plant and when was it installed?

☐ Yes ☐ No

7. What is your average effluent water discharged per annum (in m^3) over the last three years

Year 2015	Year 2016	Year 2017
☐Less than 10,000	☐Less than 10,000	☐Less than 10,000
☐ 10,001 – 50,000	☐ 10,001 – 50,000	☐ 10,001 – 50,000
☐ 50,001 – 100,000	☐ 50,001 – 100,000	☐ 50,001 – 100,000
☐100,001 – 500,000	☐100,001 – 500,000	☐100,001 – 500,000
☐500,001 – 1,000,000	☐500,001 – 1,000,000	☐500,001 – 1,000,000
☐Above 1,000,001	☐Above 1,000,001	☐Above 1,000,001

8. Have you invested in any effluent treatment measures or water reduction measures?

☐ Yes ☐ No

9. If the answer to question 5 above is yes, which one? Please describe what measures you took?

____

____

____

____

____

____

____

10. How much did it cost you to invest in the measures above in KShs?

☐ None

☐less than 100,000

☐ 100,001 – 500,000

☐ 500,001 – 1,000,000

☐1,000,001 – 5,000,000

☐5,000,001 – 10,000,000

☐Above 10,000,001

11. Do you reuse or recycle any of the water that is treated after the effluent treatment system?

☐ Yes ☐ No

12. How much water is reused or recycled from the treated effluent water?

☐None

☐ less than 10,000

☐ 10,001 – 50,000

☐ 50,001 – 100,000

☐100,001 – 500,000

☐500,001 – 1,000,000

☐Above 1,000,001

13. Have you experienced any reduction in the amount of water used for your manufacturing processes?☐ Yes ☐ No

14. If the answer to the question above is yes, what is the estimate volume of water reduction that you have experienced over the last three years (in m^3)

Year 2015	Year 2016	Year 2017
☐None	☐None	☐None
☐ Less than 10,000	☐ Less than 10,000	☐ Less than 10,000
☐ 10,001 – 50,000	☐ 10,001 – 50,000	☐ 10,001 – 50,000
☐ 50,001 – 100,000	☐ 50,001 – 100,000	☐ 50,001 – 100,000
☐ 100,001 – 500,000	☐ 100,001 – 500,000	☐ 100,001 – 500,000
☐500,001 – 1,000,000	☐500,001 – 1,000,000	☐500,001 – 1,000,000
☐Above 1,000,001	☐Above 1,000,001	☐Above 1,000,001

15. How has the established effluent discharge regulations by NEMA mainly affected the operational performance by this company? ……………………………………………..

……………………………………………………………………………………………

……………………………………………………………………………………………

16. How has the established effluent discharge regulations by NEMA affected water use and consumption by this company? ……………………………………………………………

....

....

17. Has the established effluent discharge regulations by NEMA affected the company's water security? ………………………………………………………………………………...

18. If yes, in 17, what aspect of water security has been affected? (Kindly state)……………..

……………………………………………………………………………………………

……………………………………………………………………………………………

Thank you very much for taking time to complete the survey.

Joy Busolo,

MCom Development Finance Student

Univeristy of Capetown

7.2. APPENDIX II: INTERVIEW GUIDE FOR NCWSC

Purpose

The purpose of this survey is to establish whether the introduction of NEMA effluent water quality regulations has led to compliance of effluent water quality discharged by manufacturing industries. With increased population and urbanization, there has been a strain on the available water resources leading to a gap in supply and demand of water supply, the survey also aims to collect information about the water security risks faced by manufacturing industries because of this.

The introduction of water quality regulations would lead to improved water quality discharged by industries into the sewerage system, this survey aims to establish whether there has been an improvement in the quality of water discharged by industries into the NCWSC sewerage reticulation system and whether these regulations have reduced the operation and maintenance costs of the sewerage system.

The information you will provide by filling out this questionnaire will be used for academic purpose only and strictly remain confidential.

Instruction

This survey has 12 questions and will take approximately 10 minutes to complete.

Section A: Compliance rates of manufacturing companies with effluent waste water discharge regulations

1. How many clients do you have registered as trade clients under your area of coverage?

   ☐ less than 10,000

   ☐ 10,001 – 50,000

   ☐ 50,001 – 100,000

   ☐ 100,001 – 500,000

   ☐ 500,001 – 1,000,000

☐ Above 1,000,001

You are free to provide an exact number if available _________________________

2. Do they all have permits to discharge their effluent water to the sewerage system

☐ Most of them – above 75%

☐ Half of them – about 50%

☐ Less than half – less than 50%

☐ None of them have -

3. How do you ensure that the quality of effluent discharged is compliant with the NEMA – Water Quality regulations?

____

____

____

____

4. How is the quality of effluent water discharged (with respect to compliance with trade effluent charges) from your sewage treatment plants over the last three years?

2015	2016	2017
☐ Fully compliant	☐ Fully compliant	☐ Fully compliant
☐Partially compliant	☐ Partially compliant	☐ Partially compliant
☐ Does not compliant	☐ Does not compliant	☐ Does not compliant

Section B: Effects of trade effluent charges on operational performance of Nairobi City Water and Sewerage Company

5. How many sewage treatment plants do you have in the Nairobi area? _____________

6. Does contaminated effluent water quality affect your sewerage reticulations systems?

☐ Yes ☐ No

7. Does contaminated effluent from trade clients/manufacturing industries affect your waste water treatment plants?

☐ Yes ☐ No

8. Which common contaminants in the effluent water affect the performance of the treatment plants?

☐COD (Chemical Oxygen Demand)

☐BOD (Biological Oxygen Demand)

☐Chemical compounds (Nitrates, Sulphates, Carbonates, Acids,

☐Heavy metals (Mercury, Lead, Silver etc

☐Suspended solids (sand, plastics, fibres,)

9. What is your average operational and maintenance costs of the sewerage treatment plants for the last three years?

Year 2015	Year 2016	Year 2017
☐Less than 10,000	☐Less than 10,000	☐Less than 10,000
☐ 10,001 – 50,000	☐ 10,001 – 50,000	☐ 10,001 – 50,000
☐ 50,001 – 100,000	☐ 50,001 – 100,000	☐ 50,001 – 100,000
☐ 100,001 – 500,000	☐ 100,001 – 500,000	☐ 100,001 – 500,000
☐500,001 – 1,000,000	☐500,001 – 1,000,000	☐500,001 – 1,000,000
☐ Above 1,000,001	☐ Above 1,000,001	☐Above 1,000,001

Section C: Effects of trade effluent charges on water security

10. In your opinion, how has the introduction of NEMA effluent water quality regulations affected the following aspects of water security in Nairobi County?

	Greatly Increased	**Increased**	**Moderately**	**Reduced**	**Greatly Reduced**
Water stress					
Water scarcity					
Water coverage					
Water service continuity					
Drinking water quality					

Section D: Water security risks faced by manufacturing companies

11. Kindly state the main water security risk facing Nairobi County residents? ………….
…………………………………………………………………………………………
………………………………………………………………………………………..
12. What is the main water security risk facing manufacturing company in Nairobi County?...
....

Thank you very much for taking time to complete the survey.

Joy Busolo,

MCom Development Finance Student

Univeristy of Capetown

This research has received ethical consent and has been approved by the UCT Commerce Faculty Ethics in Research Committee.

7.3. APPENDIX III: TIME SCHEDULE

Gant Chatt Work Plan for the Research from January, to October, 2018

Activities	February to August, 2018					September to October, 2018				
Topic and Proposal Development										
First Proposal Corrections										
Second Proposal Corrections										
Field work and Data Collection										
Data Analysis, Report Writing and Submission										

7.4. APPENDIX V: BUDGET

Item	**Quantity**	**Cost Per Unit (Kshs.)**	**Total Cost (Kshs.)**
Stationery and Technical Requirements and Expenses			
Writing pads	6	50	300
Biros pens	6	20	120
Rulers	2	50	500
Stapler	1	500	500
Whiteout	1	150	150
Flash disk	1	1000	1,000
Publication Costs			
Printing of instruments	5 pages	50	250
SPSS software version 23	1	2500	2500
Data analysis	50 pages	500 x 50	25,000
Photocopying of instruments	23 copies (23 X 2 = 46 pages)	4 per page	184
Typing of Report	66 pages	20	1320
Printing of Project Report	6 copies (66 X 6 = 396 pages)	10 per page	3960
Project Report Binding	6 copies	500 per copy	3,000

Research Assistants	2 X 6 Days	1500 per day	18,000
TOTAL			**56,964**