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An Evaluation of the Compliance of the Water Pollution Control Rules in Port of Spain, Trinidad

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Abstract: *Water quality is a growing concern throughout the developing world and the effects of water pollution can be very costly. Preventing and cleaning up pollution in developing countries are met with many structural obstacles, particularly economic ones. To address the problems of environmental degradation due to land based water pollution, Trinidad and Tobago introduced, in 2001, the Water Pollution Rules (WPR) to regulate the quality of effluent discharged to the environment. In 2009, the EMA began issuing Water Pollution Permits (WPPs) to facilities whose effluent contained pollutants outside the permitted levels. This paper reports on compliance to the WPR at selected facilities in the Port of Spain watershed in Trinidad. The study found that the management of facilities would not have volunteered pollution remedial actions in the absence of WPR and WPP. Moreover, the results of policy implementation appear to be quite encouraging. Overall, the compliance for the monitored stations ranged from 20% to 75% which is considered acceptable in the early stage of implementing the WPR. To improve the success of WPR, consideration should be given to the implementation of the WPR according to the polluter-pay-principle and/or increasing the fines and penalties of enforcement. It is recognised that the WPR as currently implemented cannot guarantee the desirable water quality.*

Keywords: *Pollution control, rules, compliance*

1. Introduction

In developing countries, population growth and rapid urbanisation, together with changes in lifestyle and economic development, have heightened the demand pressure on the limited water resources thereby reducing the quality of these resources. The costs associated with water pollution can be high in developing countries in terms of addressing health related issues, environmental degradation, reduced quality of life and the clean-up requirements in the future. Preventing and cleaning up pollution in developing countries are met with many structural obstacles, particularly economic ones. In practice, capital is rarely available to invest in equipment to control pollution unless there is pressure from government through the enforcement of regulations. Generally, governments are rarely motivated to regulate industries unless there are compelling reasons to do so, and there is pressure from their citizens (Guidotti, 1998). Notwithstanding, some developing countries are taking action to address the problems of pollution by relying heavily on the implementation of conventional regulatory approaches such as mandatory emission limits and technology standards (Blackman, 2006).

In Trinidad and Tobago (T&T), land based sources of water pollution pose a major threat to water resources. In the absence of appropriate legislations in Trinidad and Tobago, wastewater has been discharged from industrial, mining, commercial and manufacturing facilities to watercourses for many decades, compromising the quality of surface and coastal waters. Similarly, other diffused sources of water pollution, such as, urban and agricultural runoff, also played a part in the degradation of water quality. The effects of pollution on the water resources have prompted some research interest. For example, a number of studies documented incidents of pollution on key water resources (Sampath, 1982; Siung-Chang *et al*., 1987; Regulated Industries Commission, 2004; Lucas and Alkins-Koo, 2004). Other studies have considered the impacts of heavy metals and agricultural chemicals in water resources (Ramsingh, 2009; Sharda, 2010). Nonetheless, not much relevant scientific information has been available in the past to provide a quantitative assessment of water quality in Trinidad and Tobago, and where data are available, they have not been reliable compilations from which to determine the state of water quality or to estimate trends (EMA, 2005).

This is because the monitoring of water quality parameters has generally been given low priority; the technical base for monitoring water quality is weak; there is lack of coordination between agencies; and key indicators for assessing water quality, particularly biological indicators are limited. The earlier legislations enacted to treat with environmental management of water pollution were ad hoc and non-specific, and they fell under the remit of various ministries and departments of government. As a result, effective enforcement of these legislations was stymied and lacked institutional and legal focus. In order to address the problems of water pollution, the Water Pollution Rules (WPR) were introduced (EMA, 1999).

Safeguarding the quality of water is important to peoples' health. It is therefore, necessary to ensure that adequate systems to monitor water quality are in place and that such systems are effective. The EMA recognizes the limitation of the WPR in that the primarily focus is on end-of-pipe or point source. The WPR do not address the problem of non-point source pollution, that is, pollutants derived from diverse and diffuse sources moving over land and through the ground such as fertilizers, pesticides, and oil and grease from urban runoff (EMA, 2014). Groundwater aquifers are particularly vulnerable to this source of pollution. Non-point pollution is harder to locate and control than point sources and can explain why authorities generally tackle end-of-pipe pollution as a first step.

The WPR require water quality monitoring which is important to detecting incidents of water pollution and in measuring the level of compliance and is critical to understanding the impact of water pollution on the environment. However, it has been observed that one of the most important issues contributing to water pollution has been the lack of enforcement of environmental Legislation (The Water Resources Agency, 2001). Ultimately, two questions that need to be answered in the context of the WPR are (1) what is the level of compliance? and (2) are the rules leading to improved water quality? While the second question is critical to judging the efficacy of the WPR, it requires a more broad-based research effort.

In 2009, the EMA began issuing Water Pollution Permits (WPPs) to end-of-pipe pollution facilities whose effluent contains pollutants outside the levels permitted (EMA, 2009). The paper investigates the performance of some of these facilities and is therefore limited to the first question above. Consequently, it reports on the assessment of compliance to pollution parameters which are set for seven facilities operating in the Port of Spain watershed. It also gleans from interviews and surveys, the lessons learnt from implementation of the WPR.

2. Background

Water pollution prevention and control measures are critical to improving water quality and reducing the need for costly water and wastewater treatment. Since water pollution can come from many different sources, a variety of pollution prevention and control measures are needed (EPA, 2013). Since governments have a primary duty to protect people and their properties, pollution control is a legitimate function of government. As such, governments have a role to ensure that polluters pay for the damage they cause and are restrained from causing harm in the future by establishing a polluter-pay-principle (PPP). The PPP is one of the fundamental principles of modern environmental policies. The charge is usually added by the polluter to the production cost of the goods and is passed to the consumer (Munir, 2004). This approach is rarely embodied in environmental laws (Alder, 1995).

One of the earliest interventions to address water pollution was the Federal Water Pollution Control Act of 1948 in the United States. This Act was radically amended in 1972 in response to increasing public awareness and concern for controlling water pollution, giving rise to the Clean Water Act (CWA) (EPA, 2014).

Until the 1990s, there was a scarcity of rigorous studies on pollution control in developing countries. However, there was convincing casual evidence that regulations to protect the environment were ineffective or unnecessarily costly (Eskeland and Jimenez, 1992). Since then, the growing interests in tackling the worsening problem of air and water pollution in developing countries have resulted in a robust debate among policymakers and academics about the pros and cons of using economic incentive policies instead of, or alongside, command-and-control (CAC) policies to reduce pollution (Blackman, 2006).

The CAC policies, which proliferated during the 1970s as the preferred approach to environmental control, were enacted to bring about a change in behaviour. It was used as an enforcement machinery to get people to obey the law and typically required polluting facilities to use specified abatement devices or to cap emissions at prescribed levels. It dominated policy in developed countries because there was greater focus on remediation rather than comprehensive prevention techniques (Bocher, 2012). The use of CAC policies may be a useful initial approach, particularly, when there is limited information and the environmental damage is a serious concern (Di Falco, 2012). The observed results of the implementation of command-and-control policies, however, are in general not always very encouraging (Eskeland and Jimenez, 1992; Russell and Vaughan, 2003; Blackman, 2009). Consequently, it is not surprising that the implementation of market-based instruments or economic incentives for regulation has been on the increase due, in part, to the disenchantment with CAC approach (Harrington and Morgenstern, 2004).

Market based instruments or economic incentive policies provide financial rewards, including the use of taxes and subsidies, as incentives for compliance with water quality standards (Baldwin and Lodge, 2011). Economic incentive policies have the dual benefits of motivating polluters to cut emissions in a cost-effective manner while, at the same time, encouraging regulatory authorities to improve permitting, monitoring, and enforcement of water quality standards (Blackman, 2009). The general success of marked-based instruments in pollution control has been reported in the literature

(Seroa da Motta, 2006; Blackman, 2010). Market based instruments are often considered as an alternative to CAC however, in reality they co-exist. The success of market based instruments depends upon a well-functioning monitoring and CAC system, including properly functioning institutions (Di Falco, 2012).

The success of environmental policies in reducing water pollution is varied. In India, where environmental regulations are patterned on those from the United States and Europe, Greenstone and Hanna (2011) found that they were ineffective. Nonetheless, based on the Indian experiences, they concluded that environment regulations can be enforced successfully in countries with relatively low levels of income and weak institutions. In Columbia, notable progress has been reported in pollution control of water bodies (Kathuria, 2006). In this case, a strategy of collaboration between government, local business and communities encouraged the development and implementation of plans for cleaner technologies by many companies.

Some environmental regulations have been unsuccessful because they do not match the technical requirements and economic reality of the country or region, or because they do not take into consideration the institutional capabilities of the society that has to implement these regulations (Singh and Rajamani, 2003). To improve the level of success, some countries include, under the terms of a permit, compliance promotion programmes and activities. Although these programmes are very often comprehensive, the compliance rates remain unsatisfactory as detecting and prosecuting non-compliance are complex, as well as time and resource consuming (GFSD, 2004).

The starting point for structured water pollution management is the establishment of adequate legislation. However, critical to the effectiveness of the legislation is the ability to obtain compliance. In developed countries, full compliance with environmental regulations was rarely observed in the past. In the USA, sources in violation for air pollution was 65% (Russel, 1990), in the United Kingdom, compliance were sometimes as low as 50% (Heyes, 2000), while in the Netherlands, 67% of industries complied with the Surface Water Pollution Act (Prinsen and Vossen, 2002). In less developed countries such as China, Tanzania, Nigeria, Rwanda and Kenya, the levels of compliance with the environmental laws are below 59% (Ostrovskaya and Leentvaara, 2011).

In developing countries, compliance is highly dependent on the governmental willingness to enforce regulations. Enforcing agencies are often not mature enough and lack the ability and capacity to perform their activities properly. Further, there is a lack of formalised procedures to plan and set priorities that can help enforcers to use their limited resources more productively (Ostrovskaya and Leentvaara, 2011).

3. Trinidad and Tobago Water Pollution Rules

The WPR of T&T impact on and apply to a very wide cross section of the community, ranging from small scale beauty salons to heavy industries. Compliance with the WPR and cooperation with the EMA are necessary steps in facilitating the implementation of an effective water resource management strategy (Rambarath-Parasram, 2007).

Following the 1992 Earth Summit, the Trinidad and Tobago Government committed itself to addressing national environmental issues and to improving environmental performance (GOTT, 2012). In March 1995, the Environmental Management Act (EM Act) which established the EMA was passed. The EMA is mandated to write and enforce laws and regulations for environmental management, educate the populace about national environmental issues, control and prevent pollution and conserve the country's natural resources (GOTT 2011). As a result, a National Environmental Policy (NEP), which was designed to promote conservation and encourage the wise use of the environment, was adopted in 1998. A key principle of the policy is that the cost of preventing pollution or minimizing environmental damage due to pollution is to be borne by those responsible for the pollution (EMA, 1999). In keeping with this principle, the EM Act (GOTT, 2000a) mandated that the EMA determine the sources, distribution and types of water pollution, and develop a Water Pollution Management Programme to control and reduce the water pollution. The primary policy instrument used for achieving these objectives is the permit system of the WPR (GOTT, 2000b).

"The Water Pollution Rules 2001 (as amended) became operational in May, 2007 with the aim of ensuring that industries in Trinidad and Tobago control and reduce the volumes and concentrations of pollutants discharged in their waste water. Over time it is expected that the quality of our Inland Surface Waters, Coastal Nearshore, Marine Offshore, and Environmentally Sensitive Areas and Groundwater would improve" (EMA, 2014).

There are two major processes for the implementation of the WPR. First, there is a Source Registration (SR) where a comprehensive register of water polluters is generated from identified sources based on vulnerable watersheds. Facilities that regularly discharge water pollutants into the environment at or above the specified levels are required to complete and submit an application to the EMA for SR (GOTT, 2001b). During the SR process, pollution levels of discharges are checked against acceptable benchmark levels. A facility not meeting the benchmark is identified as a water pollution source and is issued a Source Registration Certificate (SRC) and is monitored over a period of three years. A SRC does not by itself represent any endorsement, licence or permit to operate by the EMA.

The second phase of the implementation of the WPR, hereafter referred to as the permitting phase, is the process to control and reduce the volume and concentration of effluent to meet the permissible levels. The permitting phase is initiated when monitored parameters exceed the permissible levels during the SR phase. The EM Act mandates the EMA to establish procedures for the issuance of a Water Pollution Permit (WPP) to authorise any facility to discharge wastewater under specific conditions. This controls water pollution by regulating point sources pollutant discharges. A WPP supersedes the SRC and is issued for a maximum period of five (5) years in the first instance. The terms and conditions of WWP include:

- Approved effluent discharges into receiving waters;
- Location of sampling point for compliance monitoring;
- Parameters/substances to be monitored at each sampling point;
- Monitoring schedule which outlines the frequency of sampling;
- Interim and final discharge limits for each pollutant; and
- Appropriate monitoring and reporting regime for effluent discharges, influent and ambient water quality.

The WPP is based on the acceptable benchmarks for 29 parameters. These are set according to four (4) specific receiving environments which are inland surface water, coastal near-shore, marine offshore, environmentally sensitive areas and/or groundwater. When identifying facilities requiring permits, the Authority considers the following criteria:

- Facilities located in watersheds vulnerable to surface water pollution;
- Proximity to sensitive receptors;
- Discharges into sensitive environments; and
- Complaints and compliance history.

During the permitting phase, permit holders must take measures to improve the operations so that compliance could be achieved. They are also required to submit a Pollution Control Plan (PCP), a Quality Assurance Project Plan (QAPP) and a Best Management Practices Plan (BMPP) to the EMA.

The EMA has already accepted that the impact caused by non-point source pollution is important and requires serious attention and action in order for it to achieve its mandate of clean water for all. A non-point pollution management programme has been proposed to complement the WPR. This proposed non-point source pollution management programme is expected to satisfy the long term goal of protecting Trinidad and Tobago's waters from further degradation (EMA, 2014).

The starting point for the review of the implementation process of the WPR in Trinidad and Tobago was a comparison between the legislative structure for the implementation of the WPR in T&T and three other developing countries namely Indonesia, Columbia and Poland. The following similarities were observed:

- The main environmental legislation had to be complemented by subsequent subsidiary legislation;
- The establishment of an Environmental Management Authority; and
- The self-reporting requirement of the permittee.

The following features, found in the countries, considered were absent in T&T:

- Revenue generation from the licensing system;
- Incrementally increasing stringency in the standards; and
- Decentralisation of the policing responsibility.

4. Methodology

4.1 Study Site

The study site, Port of Spain watershed, has been identified as having a high risk of vulnerability to water pollution from land based activities. In total, forty-seven (47) facilities have been registered as sources of water pollution under the SR process. Among them, seven (7) of the eight facilities that have been issued WPPs between 2010 and 2011 were the focus of this study. These facilities include chemical manufacturing, food and beverage processing, vehicle repair and maintenance, energy related processes, and waste collection and disposal.

4.2 Data Collection

Self-monitored pollution parameters data, which were collated in Discharge Monitoring Data Reports (DMDR) and submitted monthly to the EMA, were analysed. As a requirement of the WPP, permittees are required to collect and analyse samples according to the EMA's approved QAPP. The QAPP identifies the quality assurances and quality control measures to be undertaken in the collection and analysis of samples of wastewater and the reporting of the acquired results. Each permit includes a monitoring schedule which specifies the parameters to be monitored at specific discharge points and the frequency of monitoring. A daily value for each parameter is determined by taking a minimum of four (4) grab samples over the operational cycle of a day.

Data for periods of up to two and a half years prior to 2013 were available. The pollution parameter values were compared to benchmark permissible levels. Table 1 shows the parameters and the companies that were analysed. The data were checked for consistency and accuracy by comparing them with the supporting data records (such as calibrations, chain of custody documents, preservation of sample methods, sample dates, holding times and analysis dates). The PCP, QAPP and BMPP (EMA, 2005) that were submitted to the EMA, as a requirement under the WPR for each

Table 1. Parameters Monitored at Facilities with Water Pollution Permits

Type of company	Chemical Manufacturing	Energy related Processes	Food and Beverage Manufacturing			Maintenance and Repairs	Waste Collection and Disposal
	BPTL	PowerGen POS	TDL	TJCL	CGA Limited	VMCOTT	WDL
Parameter/Substance							
Temperature	✓	✓*	✓	✓	✓	✓	
Hydrogen ion (pH)	✓	✓	✓*	✓	✓	✓	
Total Suspended Solids (TSS)	✓*		✓*	✓	✓	✓*	✓*
Five day Biological Oxygen Demand (BOD_5 at 20°C)			✓*	✓*	✓		✓
Chemical Oxygen Demand (COD)	✓*	✓				✓*	✓
Total Oil & Grease (TO&G)				✓	✓		✓
Total Petroleum Hydrocarbons (TPH)	✓	✓	✓		✓	✓*	✓
Ammoniacal Nitrogen (NH_3-N)			✓				
Total Phosphorus (as P)			✓		✓		✓
Faecal Coliforms				✓*	✓*		✓*
Dissolved Hexavalent Chromium (Cr^{6+})	✓					✓	
Dissolved Iron (Fe)	✓						
Total Lead (Pb)						✓	
Total Nickel (Ni)		✓					
Total Zinc (Zn)	✓						
Total Cadmium		✓					
Flow rate	✓	✓	✓	✓	✓	✓	✓

Remarks: *- critical parameter

WPP, were reviewed to assess consistency in evaluation by the EMA personnel in approving permits. Furthermore, this review compared the proposed mitigation methods to prove industry specific best management practices.

4.3 Interviews

Unstructured interviews and online surveys were conducted among government agents, permittees and the general public to determine their levels of awareness of the WPR. Employees of the EMA were interviewed, in person, to identify how implementation success was measured. Permittees were interviewed using open-ended questions which were supplemented with telephone interviews for further clarifications. The questions were used to obtain information on:

- The effect of the WPR on the awareness of water pollution issues and behaviour towards water pollution;
- The perceptions and opinions on the effectiveness of the permitting processes, the effectiveness of the EMA in administering the WPR and ways of improving the processes; and
- The views on alternative approaches for administering WPR, for example, use of the PPP.

The interviews facilitated dialogue and allowed participants to express their experiences more freely on the application process, support systems from EMA and parity with respect to affixed fines and penalties. Structured interviews were carried out, in person, with members of the general public to assess their awareness and perception of efficacy in the implementation of the WPR. The general public were surveyed through a six question interview to obtain their perception and awareness of the nature of the water pollution problems and relevant legislation, and to assess the efficacy of the regulator.

4.4 Measuring Compliance

Ideally, non-compliance should be based on some deviation from the background concentration for particular pollutant in the environment in which it is discharged and/or inadequate implementation of the procedures, and maintenance of the control measures, required by the permit. The way in which non-compliance is to be interpreted and evaluated is not very clear for the implementation of the WPR. This leads to some level of uncertainty in determining an appropriate definition. For example, should non-compliance be taken on the basis of one parameter or a group of parameters? Failure to meet any of the set requirements could be judged a legal violation.

However, for practical purposes, selected requirements may be applied without exception. In the case in Indonesia in the 1990s, non-compliance was defined as violation of the standard for one month or more during the six-month period (Afsah et al., 1995). This approach is not considered here since samples were taken on a monthly basis and not as regular as was done in the Indonesian case. In this study, compliance is determined on a parameter basis. Thus, the level of compliance is computed as the portion of time that the effluent sample results were within the prescribed levels for a particular parameter.

5. Results and Discussions

5.1 Result-Based Monitoring

The results of the pollution parameters monitored at the different facilities are given in Tables 2 to 7. These include the mean and standard deviations of the pollution parameters for each facility from a minimum of 30 data samples taken over the review period. The percent of compliance of each of the pollution parameter is based on the data provided by each facility. At the EMA, compliance and non-compliance statuses are not clearly defined. In other jurisdictions, a facility is considered to be probable in an out-of-compliance status when the value of any compliance parameter in any compliance monitoring sample exceeds the permissible level or other applicable permit limit (UGWQP, 2014).

The level of compliance is computed as the percentage of the time that the effluent sample results were within the prescribed levels. For example, in Table 2, for food and beverage processing, Plant 1 has been fully compliant for temperature at both discharge points (A and B) and pH at discharge point B. In all other cases, the plant was not meeting the established effluent standards. Non-compliance in the parameters TSS and BOD_5 was high, exceeding the permissible level by a factor of 4 or more. At both plants, the compliance for faecal coliform was very poor; always non-compliant in Plant 1 and occasionally slightly compliant in Plant 2. The low compliance rate observed at the food and beverage plants is expected as wastewater from the fruit juice industry that will contain contaminants from the facilities cleaning and process wastewater. When this wastewater enters the natural environment it can have toxic effect on aquatic life. This suggests a case for more rigorous monitoring of the discharge points at these facilities.

As shown in Table 3, there was full compliance for temperature, iron and zinc for the paint plant. The levels of pollution from the two discharge points were different. At Location A, where the discharge flow rate was higher, there was a greater concentration and volume of pollutants.

Table 4 shows pollutant monitoring for the power generating plant. In this case, as the intake water is used mainly for cooling, the major impact is expected to be from temperature increases and from the contamination of the intake water from hydrocarbons, cleaning material and other substances that are used in daily operations of the plant. Further analysis for location A (not shown in the table) indicated that there is an increase of about 6.5°C in the temperature of the influent water. For the four discharge points and the six parameters monitored, the plant is meeting full compliance for 75% of the time. At discharge point D (where only cooling water was

Table 2. Pollutant Monitoring for Food and Beverage Plants

Parameter	Temp (°C)	pH	BOD_5 (mg/L)	TSS (mg/L)	TO&G (mg/L)	FC (counts per 100mL)	Flow Rate (m^3/day)
Permissible Level	**35**	**6-9**	**30**	**50**	**10**	**400**	**NA**
Plant 1							
Mean	29.4	6.77	447	44.835	4.52	247597	717.46
STD	1.45	0.55	360	41.86	4.27	359644	535.27
% Compliance **(A)**	100	52	0	52	91	0	
% Compliance **(B)**	100	100	48	100	91	0	
Plant 2							
Mean	31.88	7.49	26.79	42.81	43.51	646857.81	82.89
STD	3.18	0.71	12.68	103.74	97.40	720392.85	111.66
% Compliance	88	100	67	96	38	13	

Table 3. Pollutant Monitoring for the Paint Plant

Parameter	Temp (°C)	pH units)	TSS (mg/L)	COD (mg/L)	TPH (mg/L)	Cr^{6+} (mg/L)	Fe (mg/L)	Zn (mg/L)	Flow rate (m^3/day)
Permissible Level	**35**	**6-9**	**50**	**250**	**25**	**0.1**	**3.5**	**2**	**NA**
Location A									
Mean	28.59	7.75	379.08	1205.36	10.87	0.15	0.22	0.34	2607.38
STD	1.72	1.07	693.25	1324.58	35.02	0.16	0.21	0.48	5231.94
% Compliance	100	88	25	25	96	60	100	100	NA
Location B									
Mean	29.04	7.34	260.11	816.74	8.13	0.01	0.21	0.18	209.67
STD	1.46	0.70	683.98	1334.52	19.02	0.005	0.130	0.238	309.49
% Compliance	100	96	54	38	92	100	100	100	NA

discharged), there was full compliance for all pollutant parameters monitored. Hence at discharge point B, there was high non-compliance with temperature during a five-month period when the company experienced operational challenges.

At the vehicle repairs and maintenance facility, characterised by small flows, the compliance was above 60% for all the parameters (see Table 5). The large standard deviations suggest high fluctuations in the main pollutant discharges over the reporting period. However, further analysis shows small declining levels of TSS and TPH but increasing levels of COD and Dissolved Hexavalent Chromium (Cr6+). As this facility handles significant quantities of hydrocarbon in its operation, the declining trend over the reporting period may suggest that there was improvement due in part to the implementation of the WPR.

Table 6 shows the results from the parameters monitored at a distillery plant. Typical wastewater from distilleries carries appreciable organic load and the spent wash is coloured and highly acidic with an offensive odour, which poses serious environmental problems. The level of compliance for temperature, total petroleum hydrocarbons (TPH) and nitrates (NH3-N) are better than for TSS, BOD and P. It is expected that the TSS and BOD levels for such plants can be problematic due to the characteristic of the products used in the production process. However, further analysis shows that there was a moderately increasing trend of the level of BOD and TSS over the reporting period. Since there are many available cost effective methods of treating distillery wastewater, it may be necessary to introduce more stringent requirements for reducing pollution loads from the distillery plant.

For the pollution monitoring at the waste disposal facility, compliance has been achieved only for P and BOD (see Table 7). The pollutants FC and TSS are of concern since they have negative impact on public health. Nonetheless, a trend of improvement over the monitoring period has been observed for total oils and grease (TO&G), TSS and TPH.

The simple measure of compliance shows that none of the facilities were meeting all the set standards. When considering the physico-chemical and biological parameters, all the facilities were discharging within the temperature condition set, except for the power generating plant where the discharge at one location was outside the set conditions for a specific period. Thirty-seven percent of the discharge points were fully meeting the requirement for pH, while the others average about 78% with the lowest compliance being 20%. It is of note that only the waste disposal plant was meeting the BOD benchmark. The average compliance for BOD at the other discharge points monitored was 31%.The unexpected good compliance for BOD at the waste disposal plant suggests the need for an audit of monitoring process in the future.

Table 4. Pollutant Monitoring for Power Generating Plant

Parameter	Temp (°C)	pH	COD (mg/L)	TPH (mg/L)	Ni (mg/L)	Cd (mg/L)	Flow rate (m^3/day)
Permissible Level	**35**	**6-9**	**250**	**25**	**0.5**	**0.1**	
Mean	32.9	7.7	65.6	2.3	0.01	0.01	126324
STD	2.42	0.5	45.0	3.7	0.0025	0.0025	85674.
% Compliance **(A)**	100	89	85.7	100	100	100	NA
% Compliance **(B)**	45	100	91	91	100	100	NA
% Compliance **(C)**	100	100	100	96	100	100	NA
% Compliance **(D)**	100	100	100	100	100	100	NA

Table 5. The Results for the Vehicle Repairs and Maintenance Facility

Parameter	Temp (°C)	pH	TSS (mg/L)	COD (mg/L)	TPH (mg/L)	Cr^{6+} (mg/L)	Pb (mg/L)	Flow Rate (m^3/day)
Permissible Level	**35**	**6-9**	**50**	**250**	**25**	**0.1**	**0.1**	
Mean	28.9	7.8	60.4	176	26.58	0.1	0	0.09
STD	1.62	0.82	90.0	284	66.11	0.09	0	0.18
% Compliance **(A)**	100	90	64	68	89	71	100	NA
% Compliance **(B)**	100	96	85	100	85	73	100	NA

Table 6. The Results for a Distillery Plant

Parameter	Temp (°C)	pH	TSS (mg/L)	BOD (mg/L)	TPH (mg/L)	NH_3-N (mg/L)	P (mg/L)	Flow Rate (m^3/day)
Permissible Level	**35**	**6-9**	**50**	**30**	**25**	**10**	**5**	
Mean	27.9	5.89	43	271	4.36	1.08	1.55	40.4
STD	2.16	0.68	76.6	518.3	5	1.57	2.2	60.2
% Compliance **(A)**	95	20	95	20	100	100	85	NA
% Compliance **(B)**	100	94	67	6	89	95	67	NA
% Compliance **(C)**	100	80	57	48	100	100	100	NA

Table 7. Pollutant Monitoring for Waste Disposal Plant

Parameter	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	TO&G (mg/L)	P (mg/L)	TPH (mg/L)	FC (counts per 100mL)	Flow Rate (m^3/day)
Permissible Level	**50**	**30**	**250**	**10**	**5**	**25**	**400**	**NA**
Discharge point A								
Mean	59.87	17.06	NA	14.17	0.61	NA	139941	206.52
STD	49.83	9.31	NA	30.41	0.37	NA	237645	206.02
% Compliance **A**	72	100	NA	86	100	NA	53	NA
Discharge point B								
Mean	80.61	NA	116.11	NA	NA	37.4	NA	365.77
STD	96.74	NA	128.02	NA	NA	143.8	NA	363.56
% Compliance **B**	67	NA	71	NA	NA	91	NA	NA
Discharge point C								
Mean	99.93	NA	217.83	NA	NA	5.43	700844	175.7
STD	66.05	NA	360.7	NA	NA	5.61	611385	110.78
% Compliance **C**	34	NA	83	NA	NA	100	17	NA

The monitoring of COD shows that except for the power generating plant, compliance was about 63%. The non-compliance of BOD and COD has the potential to affect aquatic life in the waterways. The analysis for TSS shows that there was full compliance in less than 10% of the monitored points while the remainder averaged 70% non-compliance. An analysis for P shows that 50% of the monitored points fully complied with the benchmarks in the given permits. For TPH, 45% of the monitored points met full compliance while the average compliance of the others was 90%. On the other hand, no monitored point met full compliance for TO&G and the average compliance was 76%. In the case of heavy metals, there was full compliance for iron, lead, nickel, zinc and cadmium. At the sites monitored for chromium, compliance ranged between 80% and 70%.

As the requirements for the WPR was based on the concentration of the pollutant, no in-depth attempt was made at using flow rates to analyse the quantity of the pollutant being discharged. For example, based on the results in the study and estimates of operational durations, the distillery plant could discharge as much as 500kg, 60kg and 20kg of solids, petroleum hydrocarbons and phosphates respectively on a daily basis. However, undertaking meaningful analysis of the quantities, the information on total discharge volumes which are not now available would be required.

5.2 Observations from Survey and Interviews

Although the EMA is mandated to undertake activities for improving public awareness of the environmental legislation and wastewater management including the WPR, it was found that less than 20% of the public interviewed was aware of the activities of the EMA. It was also found that the public was not very interested in the WPR.

The EMA has acknowledged that there are sources of water pollution, which should be within the permitting process, that have not been registered. Site visits to facilities during this study found that in some cases there were more discharge points than what were approved. Furthermore, some facilities submitted renewal applications without including the additional discharge points and were issued SRC. This suggests a deficiency in the stringency of the renewal process.

Inconsistencies were found amongst the approval criteria for permit documents such as the QAPP, BMPP and PCP and the use of Best Professional Judgment in determining monitoring schedules. Although internal checklists are used for reviewing the documents, the approval process can be discretionary due to limited technical capacity and resource deficiencies.

The study found that the facilities, with WPR permits, would not have complied voluntarily with the WPR if they were not legislated. Further, there was little support for the implementation of the WPR in keeping with the PPP. Nonetheless, it was also found that there was an increased awareness of water pollution issues amongst the staff of the EMA and the facilities that were monitored and that there was an improvement in the culture with respect to water pollution. The improved culture is the result of changed/improved behaviours of staff of the EMA and the monitored facilities and their awareness of the implications of negative behaviours on the wider populace.

Facility operators agreed that the fees to the EMA were small; however, there was a general concern about the high cost of complying with the WPR. For example, in the case of Powergen, the cost of implementing the rules for the years 2001 to 2009 has been estimated at US$ 438,922 (Roberts and Little, 2011). The validity of these costs concerns needs to be examined as it was found that treatment costs in implementing water pollution rules are small and can be as low as 0.2% of the industry's total production costs (Chooi, 1984). Further, there are indications that in some cases, the quality of effluent discharged was higher than that of the receiving environment and this is prompting the call for the simultaneous monitoring of the receiving water.

The EMA management considered the WPR to be successful as measured through its observations from site visits, areal fly-overs and preliminary analyses of data. An example of the success is cited in the case of a juice making plant where discharges, once refused by the central wastewater treatment plant, are now accepted for discharge to the sewer system that conveys wastewater to the treatment plant. While concrete evidence was provided, this claim of success may be partly corroborated by an example of the reduction in the case of TO&G for the waste disposal facility as shown by the exponential trend-line in Figure 1, and the linear trend-line shown for distillery plant in Figure 2 as found in this study, respectively.

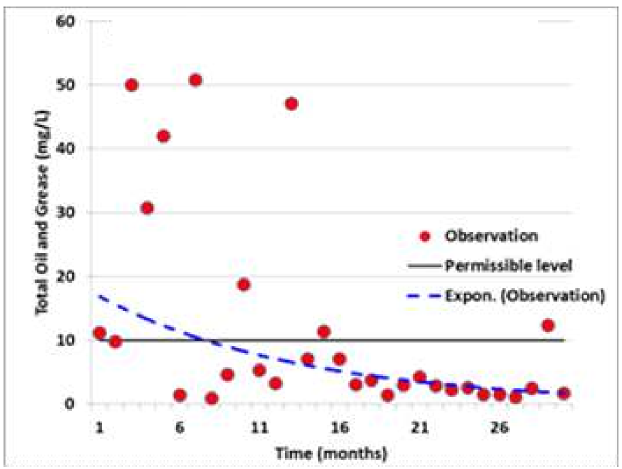

Figure 1. Total Oil and Grease in Wastewater from a Wastewater Disposal Facility

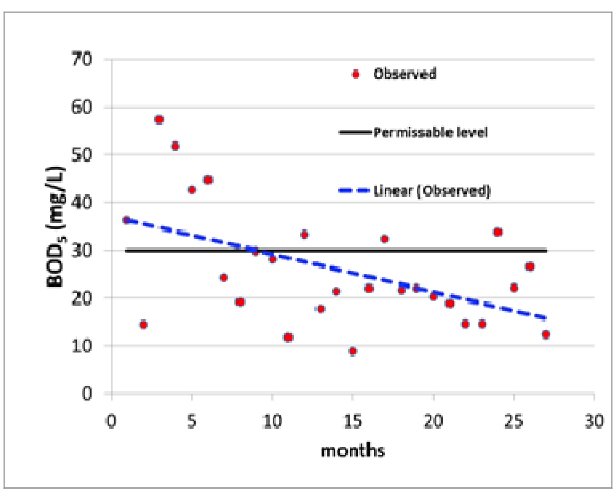

Figure 2. BOD_5 during Monitoring Period

Despite the relative successful application of the WPR, the instrument suffers from some design and implementation problems. After a facility is issued a SCR, there is no follow up from the EMA until the time for a renewal certificate. Further, the discretionary nature of the self-monitoring provides opportunities for misapplication of sampling methods and protocols which ultimately can lead to doubts about the veracity and accuracy of the data provided to the EMA and misrepresentations of the level of compliance. The challenges associated with self-reporting are exacerbated under the current implementation practices, which require that prior permission be given to the EMA for site visits. Ideally, the regulator should be able to verify information by having the ability to make random and undeclared visits. This will prevent a facility from concealing any shortcomings.

Permittees were generally unprepared for the level of involvement required by them for the implementation of the WPR. It was perceived that there could be cost reduction if the EMA played a more facilitative role in the preparation of the respective plans (QAPP, BMPP and PCP) and operated a laboratory for the required tests. Further, many small- and medium-sized firms can have difficulty to internalise environmental costs in their products or finance cleaner technologies. As a result, the EMA can encounter difficulties in enforcing the implementation of the WPR by these firms.

6. Conclusions

Although the approach used in implementing the WPR in T&T shares some similarities to those of other developing countries, the high level of success experienced in these countries has not been observed in T&T. The results from the implementation of the WPR for addressing water pollution are encouraging as they relate to the entities investigated. Overall, the compliance with the WPR for the monitored stations ranged from 20% to 75%. This can be considered satisfactory in the early stage of implementation as there is usually a lag in the impact of the application of policy instruments and it was not expected, a priori, that the EMA would ‘get it right’ immediately.

Nonetheless, in the future, full compliance would be the only acceptable condition to ensure that the desirable quality of the water resources is achieved. Water pollution permits, which were issued as part of the WPR, have not been audited to verify that facilities have implemented mitigation measures or that the best management practices were adopted to achieve prescribed standards. In the study, there was no direct attempt to capture reasons for non-compliance. However, interviewed participants indicated that there is the need to establish an "enforcement presence" and provide consistency and uniformity to sanctions imposed for non-compliance.

There is evidence to suggest that the implementation of the WPR has increased the level of awareness of water related environmental issues among the staff of the

EMA and the facilities that are monitored by the general public. At the same time, there are calls for reviewing the monitoring processes to facilitate better outcomes. In this regard, in the future, public pressure may play an important role in improving compliance.

Moreover, there are two issues that should be considered in determining the overall success of the WPR. Firstly, the issue about the number of end-of-pipe pollution entities that are currently captured and secondly, the relative impact of non-point source pollution. Given that many entities that should be captured by the WPR are not yet fully monitored, the success of the overall impact of the rules is questionable. While the paper reported only on the WPR, which focused on end-of-pipe pollution, it is recognised that the effects of non-point pollution on water quality could be such that it can be greater than that from end-of-pipe pollution (EMA, 2014). The EMA's proposed non-point source pollution management programme would require scientific assessment of water quality through in-house and or voluntary efforts.

The EMA as a regulatory institution is understaffed and may be lacking of financial resources. This can impair both monitoring of the pollution parameters and enforcement of the WPR. Hence, some reforms of the WPR are needed. As the current fines and penalties are not acting as a deterrent, it is recommended that as a first step, consideration should be given to increasing the fines and penalties of enforcement under the WPR. The potential of significant charges and fines is to increase voluntary compliance. Therefore, continuous monitoring of discharges may not be required. In the long term, consideration should be given to the implementation of the WPR according to the PPP with adequate fines and penalties of enforcement. The absence of discharge fees potentially creates disincentives for the regulatory authority to improve permitting, monitoring, and enforcement.

The legislation should be amended to allow the EMA to carry out unannounced visits. This would facilitate the establishment of an auditing mechanism for the current self-monitoring and self-reporting required by the permittees. In addition, the EMA should consider providing appropriate general and limited site-specific, compliance assistance, consistent with the primary purpose of the WPR, as this can motivate more cooperation from polluting enterprises.

One of the requests from permittees was for the EMA to set up its own laboratory. The request has some merit and is therefore recommended. This would facilitate the regularisation of the monitoring of the pollution parameters by the EMA. As T&T is well endowed with a system of freedom of information, The EMA is encouraged to have public disclosure policies that would provide information to communities, consumers and other stakeholders on environmental performance of individual polluting entities. This can raise the awareness of the general public and bring public pressure on defaulters as it creates a political dynamic that increases formal regulatory pressure on the defaulters. As a complement of the study, further studies are recommended. Such studies should aim to establish the level of non-point pollution visa-vis end-of-pipe pollution and the relationship between production levels at manufacturing facilities, effluent flow rate and effluent quality.

To implement these recommendations, the EMA would need to improve the institutional capacity for monitoring and consider greater networking amongst agencies or regional corporations involved in water resource management in order to facilitate more diligent enforcement of the WPR.

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