A STUDY ON WATER QUALITY OF GALING RIVER, KUANTAN

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ABSTRACT

Water pollution has a harmful effect on all living things that used and lives in it, and Galing River is one of the river in Kuantan that has been severely polluted. The rapid development in the catchment area of the Galing River has exposed it to various pressures that resulted in the occurrence of events such as flooding, contamination / deterioration of water quality, lack of water resources, erosion in riverbank / riverbed, squatters, and legislation in managing the river. The aim of the study was to determine the water quality status of the Galing River and classified based on Water Quality Index (WQI) and National Water Quality Standard (NWQS), Malaysia. To achieve the objectives, 9 times water samples were collected in the month from September to November 2015. Physical, chemical and biological parameters were analyzed using standard methods. The WQI was calculated using DOE-WQI based on the concentration of DO, BOD, COD, TSS, pH and NH_3^-N. Other parameters that had been considered in this study were temperature, conductivity, selected heavy metals, total coliform and E.coli. Based on results, Station 1 was categorized as Class II (clean), Station 2 was under Class III (slightly polluted) while Station 3 was classified as Class IV (polluted). The lowest WQI value was 48.07 and the highest value was 84.51. It was mainly because the low concentration of DO and high concentration of BOD, COD and NH_3^-N due to the surrounding activities such as industrial, municipal waste and effluent from residential areas. The results indicate that the Galing River is clean based on NWQS, Malaysia at Station 1 which can be used as water supply and only needed a conventional treatment. Overall, water can be supplied from the Galing River but required extensive treatment. Finally the monthly monitoring is necessary to improve the quality of the Galing River.

ABSTRAK

Pencemaran air mempunyai kesan berbahaya pada semua makhluk hidup yang menggunakan dan hidup di dalamnya, dan Sungai Galing adalah salah satu sungai di Kuantan yang telah teruk tercemar. Pembangunan pesat di kawasan tadahan Sungai Galing telah mendedahkannya kepada pelbagai unsur yang menyebabkan berlakunya peristiwa seperti banjir, pencemaran / kemerosotan kualiti air, kekurangan sumber air, hakisan di tebing sungai / dasar sungai, setinggan, dan undang-undang dalam pengurusan sungai. Tujuan kajian ini adalah untuk menentukan status kualiti air Sungai Galing dan mengelaskan berdasarkan Indeks Kualiti Air (WQI) dan Piawaian Kualiti Air Kebangsaan (NWQS), Malaysia. Bagi mencapai objektif, 9 kali sampel air telah diambil pada bulan September hingga November 2015. Fizikal, kimia dan biologi parameter telah dianalisis dengan menggunakan kaedah piawai.WQI dikira menggunakan DOE-WQI berdasarkan DO, BOD, COD, TSS, pH dan NH_3-N. Parameter lain yang turut dipertimbangkan dalam kajian ini adalah suhu, kekonduksian, logam berat, Jumlah koliform dan E.coli. Hasil kajian menunjukkan Station 1 dikategorikan sebagai Class II (bersih), Station 2 adalah di bawah Class III (sedikit tercemar) manakala Station 3 telah dikelaskan dalam Class IV (tercemar). Nilai WQI terendah adalah 48,07 dan nilai tertinggi adalah 84,51. Ia adalah disebabkan oleh aktiviti-aktiviti di sekitar sungai seperti perindustrian, sisa perbandaran dan efluen dari kawasan perumahan. Hasilnya menunjukkan bahawa Sungai Galing di Station 1 yang bersih mengikut NWQS, Malaysia, boleh digunakan sebagai bekalan air, dan hanya memerlukan rawatan konvensional. Secara keseluruhan, air boleh dibekalkan dari Sungai Galing tetapi memerlukan rawatan yang menyeluruh. Akhirnya pemantauan bulanan adalah perlu untuk meningkatkan kualiti Sungai Galing.

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LIST OF SYMBOLS

H_2O	Water compound
CO^2	Carbon Dioxide
O^2	Oxygen gas
H+	Hydrogen ions
OH-	Hydroxide ions
NNO_3	Nitric acid
HSO_4	Sulphuric acid
Cu	Copper
Pb	Lead
Zn	Zinc
Cr	Chromium
NH_3	Ammonia
NH_4^+	Ammonium
NH_3-N	Ammoniacal Nitrogen
°C	Degree Celsius
°F	Degree Fahrenheit
µS/cm	microsemens per centimetre
mL	millilitre
mg/L	milligram per litre

LIST OF ABBREVIATIONS

A-P Test	Absence-Presence Test
AAS	Atomic Absorption Spectroscopy
ANOVA	Analysis of Variance
APHA	American Public Health Association
ATSDR	Agency for Toxic Substances and Disease
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DOE	Department of Environment
DOH	Department of Health
E.coli	Escherichia Coli
EQR	Environment Quality Report
MERC	Malaysian Environmental Resources Center
MPCA	Minnesota Pollution Control Agency
MPK	Majlis Perbandaran Kuantan
N	Nitrogen
NAS	National Academy of Science
NPS	Nonpoint sources
NWQS	National Water Quality Standard
NZMoH	New Zealand Ministry of Health
TSS	Total Suspended Solid
USEPA	United States Environmental Protection Agency
WQI	Water Quality Index

CHAPTER 1

INTRODUCTION

1.1 Introduction

Water is needed by all living organisms. It plays an important role in many natural processes and is essential in countless physical and chemical reactions. Water is considered a renewable resource, renewable referring to that portion which circulates through the hydrological cycle. According to the United Nations' World Water Development Report (2003), although 70% of the earth's surface is covered by water, only 2.5% of that water is fresh and only 0.3% of that water is available for human use.

In Malaysia, river is the main supply of water resources to all human activity. There are approximately 49 major river basins which lead to the supply. However, the most worrying problem lately is, although water resources are easily available from lakes, rivers, sea and so on, the quantity of water that is clean and safe to use is so limited.

In Malaysia, there is already a standard that concerning the classification of water quality issued by DOE in relation to water pollution. Consequently, the quality of water must be controlled and treated properly, particularly in river basin areas which are the main water supply to the residents, according with the standards that have been set. Government has set some rules under Nature Quality Act 1974, which enacted and implemented to prevent and control water pollution especially blocking effluents from the industrial sector (Division of Environment, 1980).

For that reason, water quality is needed to play a role as parameter that can control the physical and chemical state of water. Water Quality also plays an important role to express classes of water for various purposes and consumptions. Water Quality also plays an important role to express classes of water for various purposes and consumptions. Water cannot simply classified by using simple observation since it will have to achieve certain requirements for physical, chemical and biological characteristics.

1.2 Problem Statement

Water pollution that may consist of physical, chemical or biological contamination has a harmful effect on all living things that used and lives in it. Galing River has a catchment area of 22.65 km^2 and is 7.7 km long that has the rapid development in the watershed area, where the upstream area is harness Semambu and its downstream areas is the heart of Kuantan. While the intermediate area is a mixed development areas such as housing and economic growth centre.

The rapid development in the catchment area of the Galing River has exposed it to various pressures that resulted in the occurrence of events such as flooding, contamination / deterioration of water quality, lack of water resources, erosion in riverbank / riverbed, squatters, and legislation in managing the river. The major issues and problems that have been identified are;

1) The rapid development in the catchment area which not care about the conservation of environmental,
2) Disposal of garbage and domestic waste from the commercial, residential, villages and squatters,
3) Toxins / chemicals waste from industrial, and sewage that is not been treated properly,
4) Waste oil from workshops,
5) Waste from wet markets / restaurants and food premises,

1.3 Objectives

1. To determine the water quality status of the Galing River.
2. To classify the Galing River based on Water Quality Index (WQI) and National Water Quality Standard (NWQS), Malaysia.

1.4 Scope of Study

This research area was located at three different stations which are upstream, downstream and the intermediate area of Galing River. The upstream of Galing River is at the industrial area of Semambu while the downstream is at the city of Kuantan which is surrounded by high density of population. Meanwhile, a mixed development areas such as housing and economic growth centre are located at intermediate area of Galing River.

The data for water quality was taken 3 times at each station within September 2015 to November 2015.

This study covers all three water quality parameters which are the physical, chemical and biological parameters. There are 11 parameters that have been chosen for this study. The parameters involved are temperature, pH, conductivity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen, total suspended solid (TSS), heavy metals, total coliform and E.coli.

The test that will be conducted for this study consists of two parts which are In-Situ test and laboratory test. As for In-Situ test, there will be four parameters will be covered using Kit probe instrument which are temperature, pH, conductivity and dissolved oxygen (DO). Equally important, laboratory test have biochemical oxygen demand (BOD) test, chemical oxygen demand (COD) test, total suspended solid (TSS) test, test for heavy metal presence (AAS test), Ammoniacal Nitrate test and Absence-Presence Test (A-P Test).

The water quality standards that involves in this study are Water Quality Index (WQI) and National Water Quality Standard (NWQS), Malaysia.

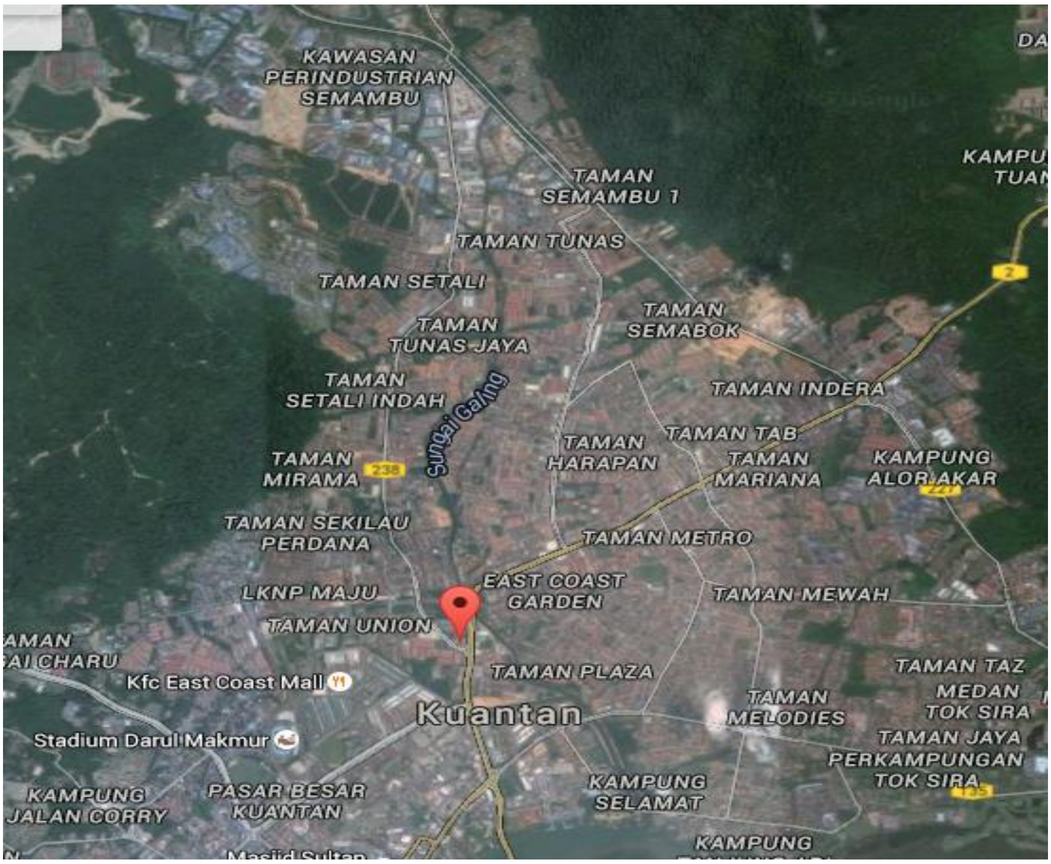


Figure 1.1: Location of Galing River

1.5 Significance of Study

Water quality index is divided into five main classes, namely Class I means water that is in its natural state and does not require treatment, Class II is suitable water used for recreation and need for conventional treatment before use. Next, Class III water that requires intensive treatment before used. Class IV is the only river water can be used for irrigation purposes while class V river is very severe polluted to be used again.

Latterly of this case study, the expected result is to attain the water quality of Galing River and make a comparison with Water Quality Index (WQI) and National Water Quality Standard (NWQS), Malaysia.

CHAPTER 2

LITERATURE REVIEW

2.1 Hydrological Cycle

The hydrologic cycle, also known as the water cycle, describes the constant and endless movement of water on, above and below the surface of the Earth. The mass of water on Earth remains fairly consistent over time but the distribution of the water into the larger reservoirs of fresh water, saline water, ice and atmospheric water is changeable depending on a wide range of climatic variables.

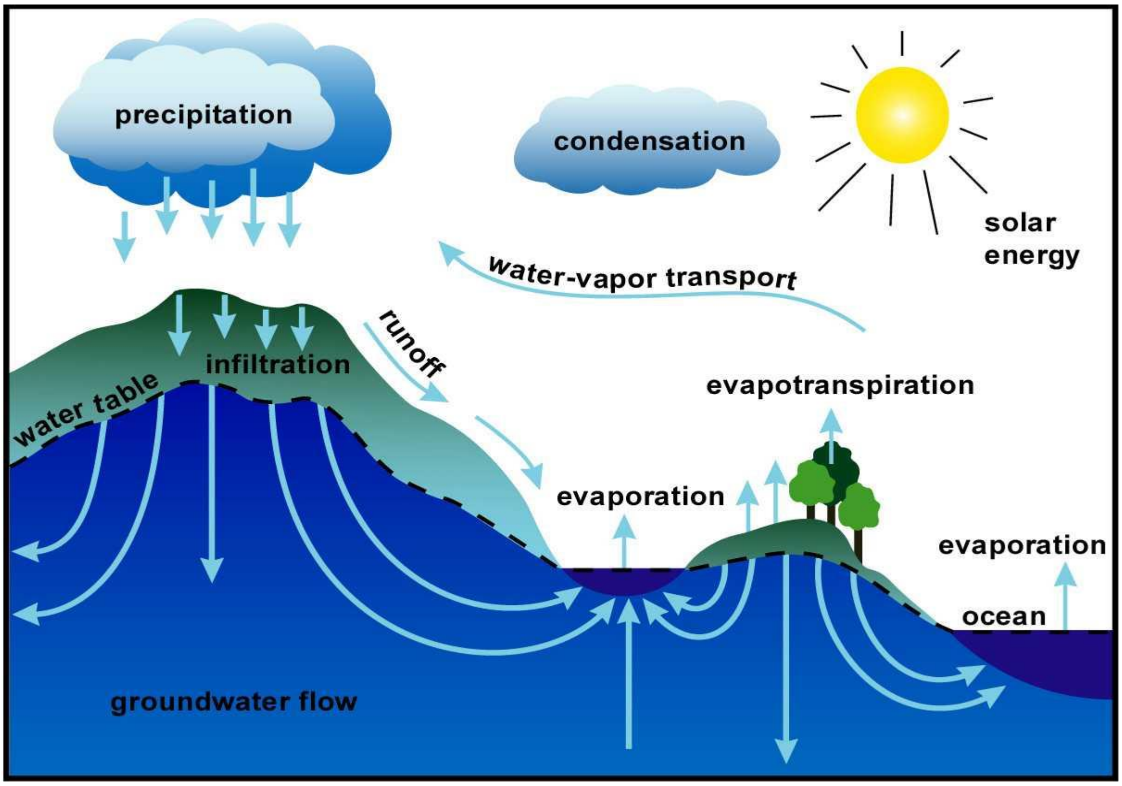


Figure 2.1: An illustration of hydrological process

The movement of the water is from one reservoir to another, in any way from the River to the sea, from the ocean to the atmosphere, by a process of physical evaporation, condensation, rain, runoff, infiltration and subsurface flow. Therefore, water goes through several phases: solid (ice), liquid and gas (vapour).

The hydrological cycle starts with the evaporation of water from the surface of the sea. As humid air is lifted, it cools and the water vapour condenses to form cloud. Moisture spreading all over the world to return to the surface as rain. When the water hit the ground, one of the processes that may occur;

(i) Some part of the water may evaporate back into the atmosphere or
(ii) Water can penetrate the surface and become groundwater.

Groundwater either seeps into rivers and ocean or released back into the atmosphere through transpiration. Water balance which remained on the Earth's surface is runoff, which empties into rivers, lakes and streams and carried back to the ocean, where the cycle will begin again.

The water cycle describes the processes that drive the movement of water throughout the hydrosphere. However, more water is “keep” for long periods of time than is actually moving through the cycle. Storehouses for the majority of all the water on Earth is the ocean. It is calculated that of the 332,500,000 mi^3 (1,386,000,000 km^3) of the world's water supply, about 321,000,000 mi^3(1,338,000,000 km^3) is stored in oceans, or about 97%. It is also estimated that the oceans supply about 90% of the evaporated water that goes into the water cycle.

2.2 Galing River

Galing River is a stream in Malaysia, located between Kampung Lapang Besar and Tanjung, and is also nearby to Kuantan and Kampung Padang Lalang. Galing River is close to Vistana Kuantan City Centre, Vistana Hotel Kuantan and Citiview Hotel. The topography around Galing River is mostly a flat-plain area. Galing River flow downstream merging with River Kuantan before going into the South China Sea. It has several tributary rivers, namely Small Galing River and Son River Galing.

Figure 2.2: Location of the Study Area

Galing River has a catchment area of 22.65 km^2 and is 7.7 km long which is 4.3 km for Big Galing while 3.4 km for Small Galing. Big Galing is a main drainage system for the east area of Kuantan. The other main drainage system that enter this river system including Small Galing (113 ha.). That covers the region around Medan Kubang Buaya and Medan Tok Sira, drainage from development area in Jalan Beserah, drainage from area around Jalan Hj. Ahmad including Bukit Restal and catchment areas around Jalan Lim Hoe Lek. The catchment area falls under the jurisdiction of the Majlis Perbandaran Kuantan (MPK).

According to the Environmental Quality Report 2010 by the Malaysian Department of Environment (DOE), water quality in Galing River are in class IV for Big Galing and class III for small Galing. This report shows that Galing River is one of the most polluted river in Pahang state. But according to Utusan Online, 2013, Galing River is now successfully restored and classified in third grade or moderately polluted.

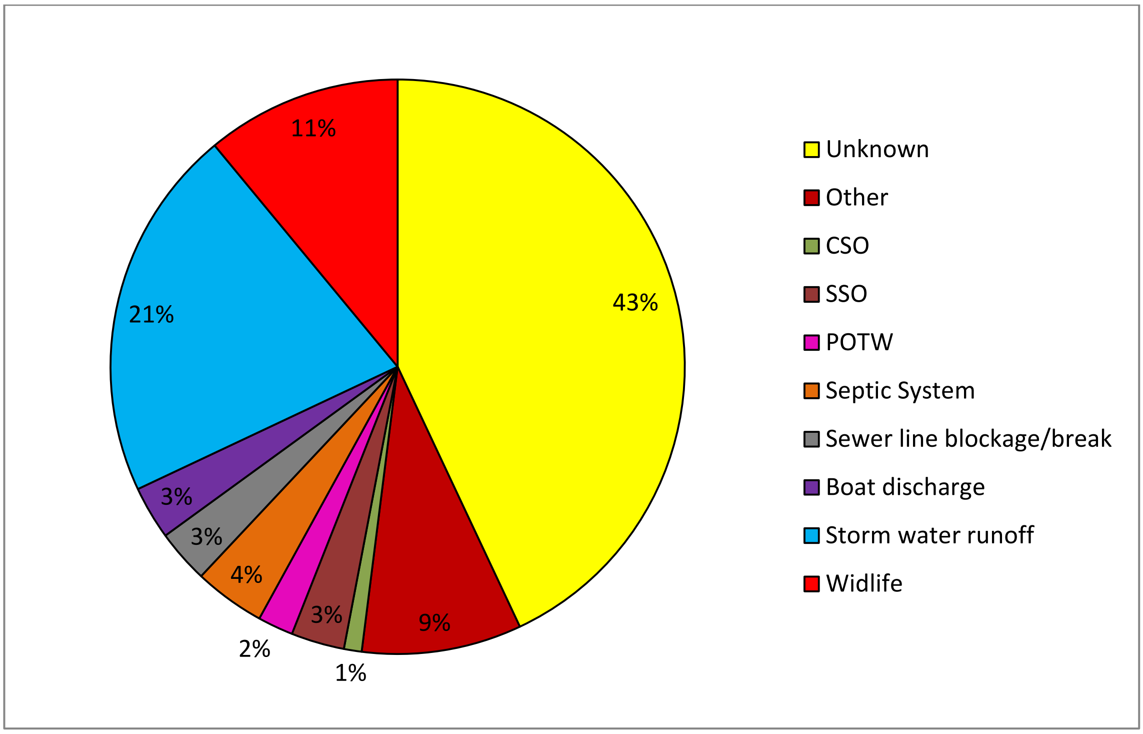
Figure 2.3: Upstream Flow of the Galing River in 2010

2.3 River Pollution

Rivers and streams drain water that falls in upland areas. Moving water dilutes and decomposes pollutants faster than standing water, but many rivers and streams are significantly polluted all around the world.

Generally, the river water was clean-water (suitable for human use) with a minimum of treatment, if it is not affected by human activities. However, the river is now used as a disposal route for solid and liquid waste. While issues of river pollution should be and are being addressed by the Government, any fundamental aspect of water supply requires the understanding and involvement of end users.

Water pollution happened when a body of water is adversely affected by addition of small or large amounts of materials (pollutants) to the water (Rafia et al., 2014). The main causes of water pollution are stated in Figure 2.4.



Notes
CSO : Combined Sewer Overflow
SSO : Sanitary Sewer Overflow
POTW: Publicly Owned Treatment Works

Figure 2.4: Distribution of main causes of water pollution

Source: US EPA

In accordance with the Environmental Quality Report (EQR), 2011 published by the Department of Environment (DOE), the level of pollution is not at worrying level, with only 39 rivers being classified as “polluted” whereas 275 is referred as being “clean” as shown in Figure 2.5. Between 2005 and 2011, there appears to be a decreasing trend of “polluted” rivers which of course results in an upward trend of “slightly polluted” and “clean” rivers (DOE, 2006). For one thing, this may appear to be good trend, and for the most part it is right, though from a water quality management perspective this may not truly be representative of the actual water quality attributes.

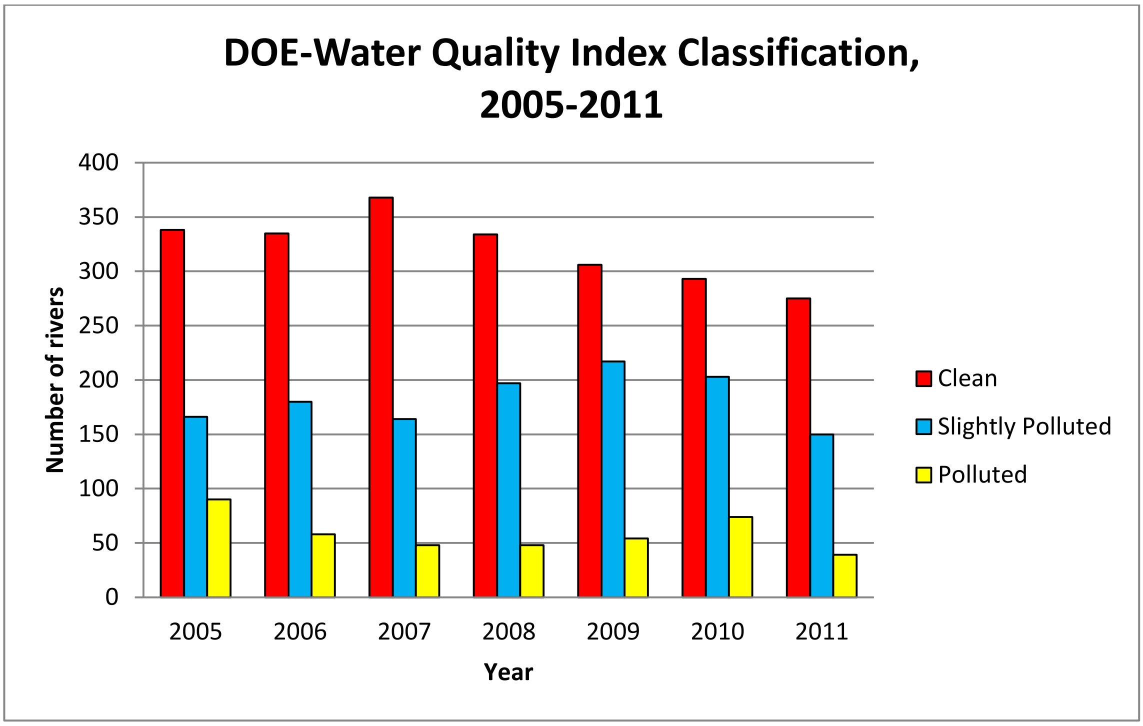


Figure 2.5: DOE-Water Quality Index Classification, 2005 – 2011

Source: DOE, 2011

2.3.1 Sources of River Pollution

Many human activities unintentionally add nitrogen and phosphorus or other pollutants to surface waters. Over many decades, urban development, farming, industry and man-made pollutants such as partially treated sewage from our homes and businesses have been pumped into waterways for disposal, causing a decline in the health of our rivers and streams. These pollutants are divided into point sources and non-point sources.

2.3.1.1 Point Sources

Point source pollution is "any single known source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack", (U.S. Environmental Protection Agency (EPA)).

Two common types of point sources are factories and sewage treatment plants. Factories, including oil refineries, pulp and paper mills, chemicals, electronics and automobile manufacturers, usually performing one or more pollutants in their discharge waters (called effluent). Several factories discharge their effluents or residue directly into a waterbody. Others treat it themselves before it is discharged, and still others transfer their wastes to sewage treatment plants for treatment. Sewage treatment plants treat human wastes and transmit the treated effluent to a river or stream.

The other way that some sewage treatment plants and factories manage their waste material is by combine it with urban runoff in a combined sewer system. Runoff apply to storm water that flows over surfaces such as driveways and lawns. Since the water crosses these surfaces, it collects pollutants and chemicals. This untreated, polluted water then runs into a sewer system directly.

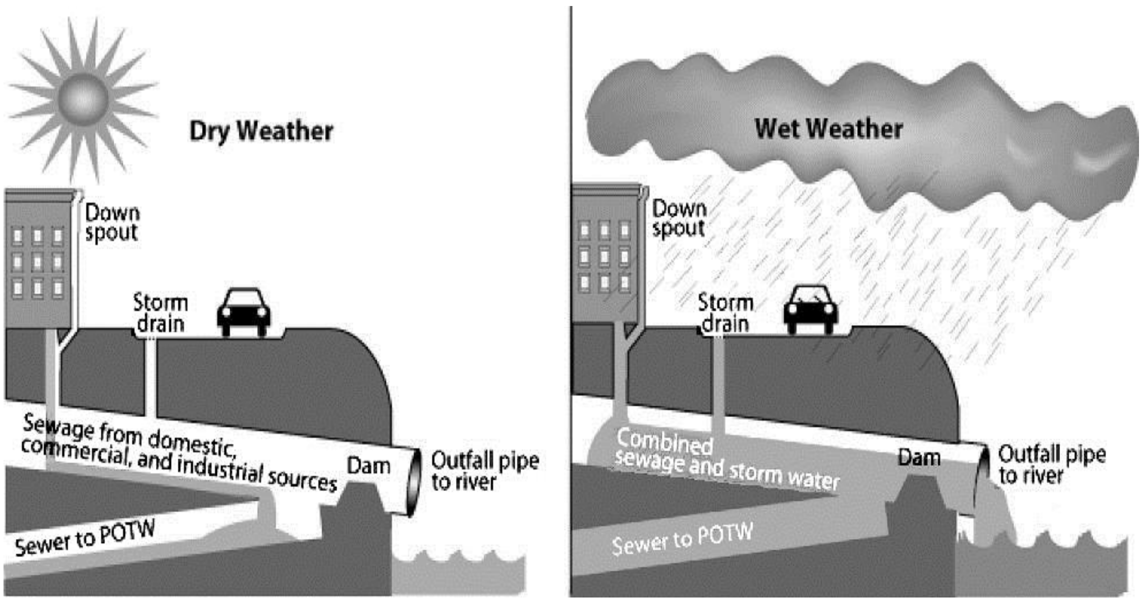


Figure 2.6: An illustration of a combined sewer system

Source: U.S. Environmental Protection Agency (EPA) [Public domain or Public domain], via Wikimedia Commons)

When it rains heavily, a combined sewer system might not be able hold the volume of water, and some of the combined runoff and raw sewage will overflow from the system. For that reason, the untreated combined runoff and raw sewage will be discharge directly into the nearest water body. This combined sewer overflow (CSO) is reviewed as point source pollution, and can affected badly to human health and the environment.

2.3.1.2 Non-point Sources

Non-point source pollution is regard to scattered contamination that does not come from a single discrete source. NPS pollution is usually referred as the cumulative effect of small amounts of contaminants gathered from a bigger area. A common case is from fertilized agricultural lands which is the leaching out of nitrogen compounds. Nutrient runoff in storm water from "sheet flow" over an agricultural field or a forest is also categorized as NPS pollution.

Non-point pollution sources are also outlined as a source of pollution occurring during hydrological events, such as rainfall and snowmelt (Klapproth and Johnson, 2009); where surface depositions are carried off by the overland flow (runoff) end up in the water column. From a water quality standpoint, non-point source pollution supply greater capacity of pollution load to the rivers than point source pollution as due to the sheer amount of volumetric discharge (MERC, 2010).

Contaminated storm water washed off from parking lots, roads and highways are being called urban runoff, and as well implicated under the category of NPS pollution. Despite this runoff is typically channelled into storm drain systems and discharged via pipes to local surface waters, it befit a point source.

2.4 Water Quality Parameters

Water quality testing is an important part of environmental monitoring. When water quality is poor, it affects not only aquatic life but the surrounding ecosystem as well. These sections detail all of the parameters that affect the quality of water in the environment. These properties can be physical, chemical or biological factors. This section also defines what the parameter is, where it comes from and why it is important to measure.

2.4.1 Temperature

Water temperature is influenced by air temperature, storm water runoff, groundwater inflow, turbidity and exposure to sunlight. In considering the health of organisms, it is important to consider their maximum temperature and the optimum temperature.

The maximum temperature is the highest temperature of water in which organisms would live for a couple of hours. The optimum temperature is the temperature at which it will thrive. The surface water temperature in dry season temperature is higher than the wet season (M.K. Mustapha, 2008).

An increase of 10°C in water temperatures nearly doubles the speed of chemical and biological reaction happening in water. Increase in temperatures leading to:

(i) Lowering the amount of Dissolved Oxygen (DO)
(ii) Enhance the Biochemical Oxygen Demand (BOD)
(iii) Speed up the nitrification and oxidation process of ammonia to nitrates (III) and (IV) which eventually lead to oxygen deficit in water.

Since the solubility of dissolved oxygen decreases with increasing water temperature, the availability of dissolved oxygen for aquatic life has been limited by the high water temperatures. Beyond that, water temperature controls various biochemical reaction rates that affect water quality. Heat sources and sinks to a water body include incident solar radiation, back radiation, evaporative cooling and heat conduction, thermal dischargers (e.g. cooling water from power plants), tributary inflows and groundwater discharge (Dep. of Water, 2009).

2.4.2 pH

Water surface pH is set for protection of fish life and control chemical reactions that are not desired. pH of any surface water bodies is defined as a measure of the concentration of hydrogen ions.

In water, the number of water molecules (H_2O) which are small will break apart or split into hydrogen ions (H+) and hydroxide ions (OH-). Other compounds that enter into the water can react with these, leaving an imbalance in the number of hydrogen and hydroxide ions.

As more hydrogen ions react, the more hydroxide ions left in the solution and water is basic; as more hydroxide ions react, the more hydrogen ions are left and water is acidic. Nevertheless, pH is a measure of the acidity or alkalinity of water soluble substances (Covington et al., 1985).

The pH is defined as the negative logarithm of the concentration of hydrogen ions in water and is determined with the help of a pH meter. pH value that is recommended for public water supply is between 6.5-8.5. The presence of mineral acids such as sulphuric acid, iron, cadmium, aluminum (effluents) make water acidic i.e., pH= 0-7 and the presence of' carbonates and bicarbonates of calcium, magnesium, and potassium make the water alkaline i.e., pH=7-14.

Increase of pH value in certain limit may not be favorable for the growth of bacteria that maintain high levels DO. A little low pH water seems to encourage the growth of bacteria, so the level of DO found very low (Prerna et al., 2014). The high values of pH may be due to attributed sewage discharged by surrounding city and agriculture fields (Medudhula et al., 2012).

High pH promotes the scale formation in the water heating system and also reduces germicidal potential of chlorine. High pH drives the formation of trihalomethanes that cause cancer in humans.