STATUS OF WATER QUALITY AS A DETEMINANT FOR THE EFFECTIVENESS OF IMPLEMENTATION OF ENVIRONMENTAL QUALITY ACT 1974 (AMENDED 1985, 1996 & 1999) CASE STUDY OF SG MELAKA LATCHMENT

MARCH 2002

BY

PAUZIAH HANUM HJ. ABDUL GHANI

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PAUZIAH HANUM HJ. ABDUL GHANI

Project Report Submitted in Partial Fulfillment of the Requirements for the Master (Environment) in the Department of Environmental Sciences Faculty of Science and Environmental Studies Universiti Putra Malaysia

Department of Environmental Sciences
Faculty of Science and Environmental Studies
Universiti Putra Malaysia

March 2002

ACKNOWLEDGEMENT

First and foremost, I would like to express my greatest gratitude to my project supervisor Assoc. Prof. Dr. Mohd. Kamil Yusoff for his supervision. He has provided me the precious time for series of discussion, valuable guidance, comments and ideas, as well as his kind assistance. Sincere thanks to the officers and staffs of the Department of Environment especially the Water Quality Monitoring Section; Encik Mohd. Norli Abdullah, for their cooperation in providing me the information needed for data analysis. Thank you also to the officers and staffs of the Melaka DOE especially, Encik Ahmad Kamarulnajuib Che Ibrahim and Puan Fauziah Mahmood for their assistance. Heartfelt appreciation also goes to Puan Rosni Ismail, Puan Norlin Jaafar, Encik Zakaria Ismail for their assistance in data preparation and data analysis, maps preparation and Encik Amirul Shazli, and Puan Faridah Amir for transforming this manu-script from the beginning until the completion of this project.

My special thanks to my beloved husband, Noorhisham Hj. Mohd. Alwi and Nurkhairiyah Noorhisham for being so understanding and supportive. They were my inspirations to perform my very best.

I would also like to extent my sincere gratitude to all the lecturers of the Department of Environmental Sciences that has impart their wisdom and knowledge, especially to Assoc. Prof. Dr. Azizi Hj. Muda and the supporting staffs for their cooperation and assistance throughout my 1½ years study in UPM. Last but not least, thank you also to all the individuals that has impart either directly or indirectly of which contributed in the completion of this project.

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Pauziah Hanum Hj. Abdul Ghani
Jabatan Sains Alam Sekitar
Fakulti Sains dan Pengajian Alam Sekitar
Universiti Putra Malaysia
43000 Serdang
Selangor, Malaysia

Projek ini mengkaji perkaitan di antara status kualiti air dengan keberkesanan pelaksanaan Undang-Undang Alam Sekitar, 1974 dengan mengguna tahap pematuhan industri-industri yang berada di dalam kawasan zon perindustrian. Tadahan Sungai Melaka dipilih untuk melihat hubungkait ini.

Status kualiti air Sungai Melaka yang berdasarkan dengan menggunakan indeks *DOE-WQI*, dipengaruhi oleh aktiviti-aktiviti guna-tanah dalam kawasan tadahan tersebut. Manakala pengurusan sumber air dan kawalan dilaksanakan menerusi penguatkuasaan Akta Kualiti Alam Sekeliling (AKAS) 1974. Dan dikuatkuasakan oleh Jabatan Alam Sekitar Melaka.

Hasil kajian menunjukkan status kualiti air menerusi *DOE-WQI* boleh digunakan untuk menentukan keberkesanan AKAS 1974 sekiranya stesen persampelan menepati tujuan tersebut. Bagi stesen-stesen yang tidak menunjukkan perhubungan, maka penilaian semula terhadap pemilihan stesen dan juga program penguatkuasaan.

ABSTRACT

Pauziah Hanum Hj. Abdul Ghani

Department of Environmental Sciences
Faculty of Science and Environmental Studies
University Putra Malaysia
43000 Serdang
Selangor, Malaysia

The project study the relationship between the status of water quality to the effectiveness of Environmental Quality Act, (EQA) 1974. Using the compliance status of industries in an industrial estate, the catchment of Sungai Melaka was chosen as the study area.

The prevailing water quality conditions of Sungai (Sg.) Melaka it can be determine by Department of Environment-Water Quality Index (DOE-WQI) arising from various land-use activities within the catchment. The water resource management and control are implemented the enforcement of the Environmental Quality Act 1974 by the Department of Environment Melaka.

The results for the statiscal analysis proved that DOE-WQI relating the status of the water quality can be used in determining the effectiveness of EQA provided that the monitoring stations are specifically design for the intended purposes. Results does not confirm the expected results calls for reassessment of monitoring and enforcement programmes.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Water quality monitoring serves a number of purposes including monitoring for assessment against compliance with national and international standard and commitment arising from international agreement or conventions. There is also a need for general surveillance monitoring which would for example serve to detect temporal and spatial differences, trends and changes in quality of surface water (Milburn, 1994 as cited in Zahit, 2000). Monitoring data generated are essential for meaningful interpretation and management decisions. Indices have been developed for resource allocation, location, ranking, standards enforcement, trend analysis, public information and scientific research (Norhayati, 1981). The water quality index is a practical means of providing a good indication of general water quality. Its main asset is that it uses collective opinion to establish a system which can be applied more objectively.

1.2 Scope of study

To assess the effectiveness of the Environmental Quality Act (EQA) 1974, the status of the water quality (polluted category) will be use as a determining factor as shown in Figure 1.1.

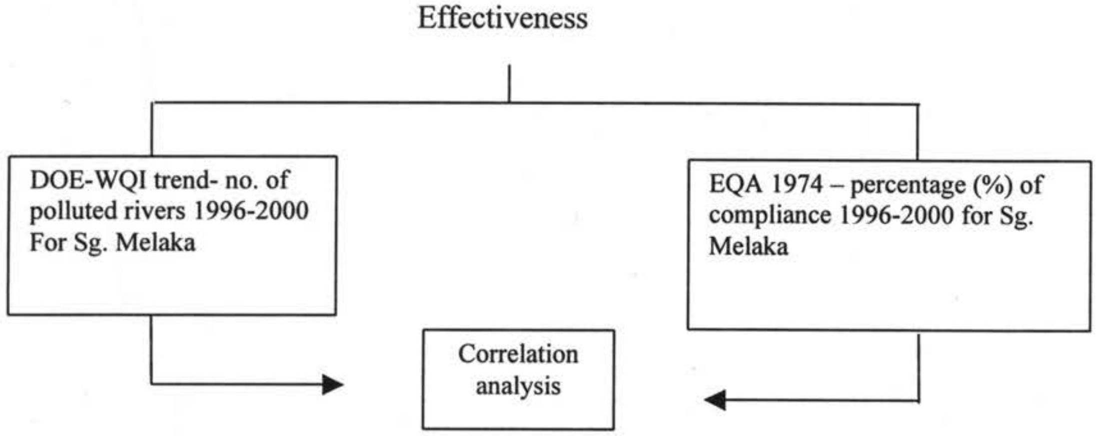


Figure 1.1: The conceptual framework of the study

1.3 Problem statement

Over the years, the effectiveness of EQA 1974 were measured through the number of compliance and non compliance of the manufacturing sector and agro-based industries, public complaints and the number of legal actions such as summons, number of prosecution and prohibition order. This study attempts to relate the effectiveness of the EQA 1974 through/by using the water quality status in the form of index as reported in the Environmental Quality Report every year.

1.4 Objectives of the study

- To determine the relationship between water quality index and the EQA 1974, by using the percentage of compliance

- To determine whether any of the individual parameter/groups of parameter used in computing the index have any significant relationship to the EQA 1974.

1.5 Limitation of study

This study only applies to the catchment area that have been selected, any attempt to generalize to other catchment will certainly required further research.

CHAPTER TWO

MANAGING WATER QUALITY IN MALAYSIA

2.1 Introduction

Water bodies can be fully characterised by the three major components: hydrology, physico-chemistry and biology. A complete assessment of water quality is based on appropriate monitoring of these components (Chapman, 1996). All freshwater bodies are interconnected from the atmosphere to the sea via hydrological cycle (Chapman, 1996). Their interaction may influence each other directly or through intermediate stages as shown in Figure 2.1

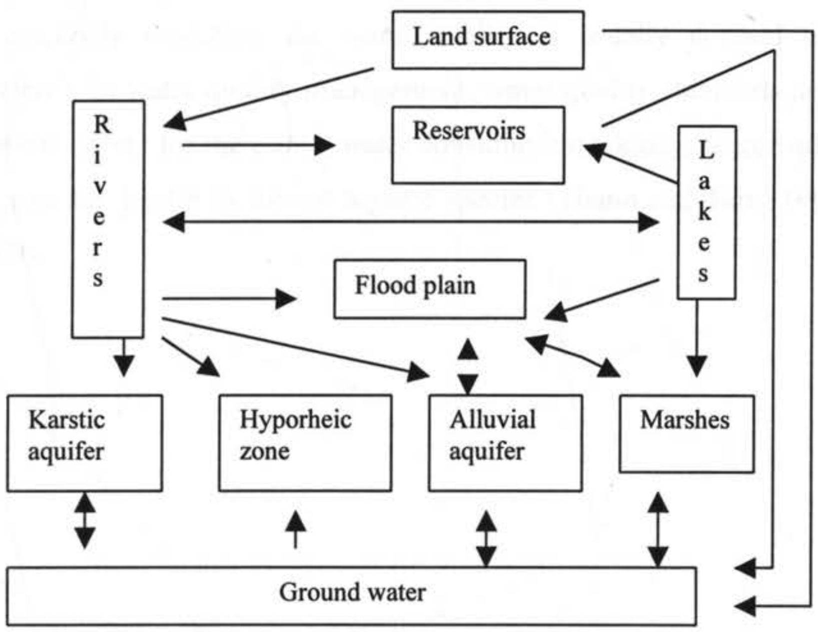


Figure 2.1 : Inter-connections between inland freshwater bodies (intermediate water bodies have mixed characteristics belonging to two or three of the major water bodies)

The impact of land use activities render a profound effect on the receiving water body especially on its quality and the aquatic species. As illustrated in Figure 2.2 where natural resources as the main inputs in economic activities, are being exploited and utilised for human consumption (Tietenberg, 1996 as cited in Zahit, 2000). Examples of human activities that render devastating impact on the receiving water body are the uncontrolled land use for urbanization, deforestation, industrialization and agriculture, which discharge suspended solids, toxic and hazardous substances, noxious liquids, from solid waste deposits, organic and inorganic substances, fertilizers and pesticides. Water quality degradation occur in two phase; first phase shows an alteration in water quality with evidence of human impact but without any harm to biota or restriction of water use. Next phase consists of some degradation of water quality and possible restriction of specific water uses because recommended water quality guidelines may be exceeded (Chapman, 1996). Once maximum acceptable concentrations for selected variables in relation to water use have been exceeded, or the aquatic habitat and biota have been markedly modified, the water quality is usually defined as polluted (Chapman, 1996). In water quality management, water quality standards are set-up to ensure the health safety for the public water consumption taking into consideration on the survival and the health factors of aquatic species (Thann and Tam, 1990 as cited in Zahit, 2000).

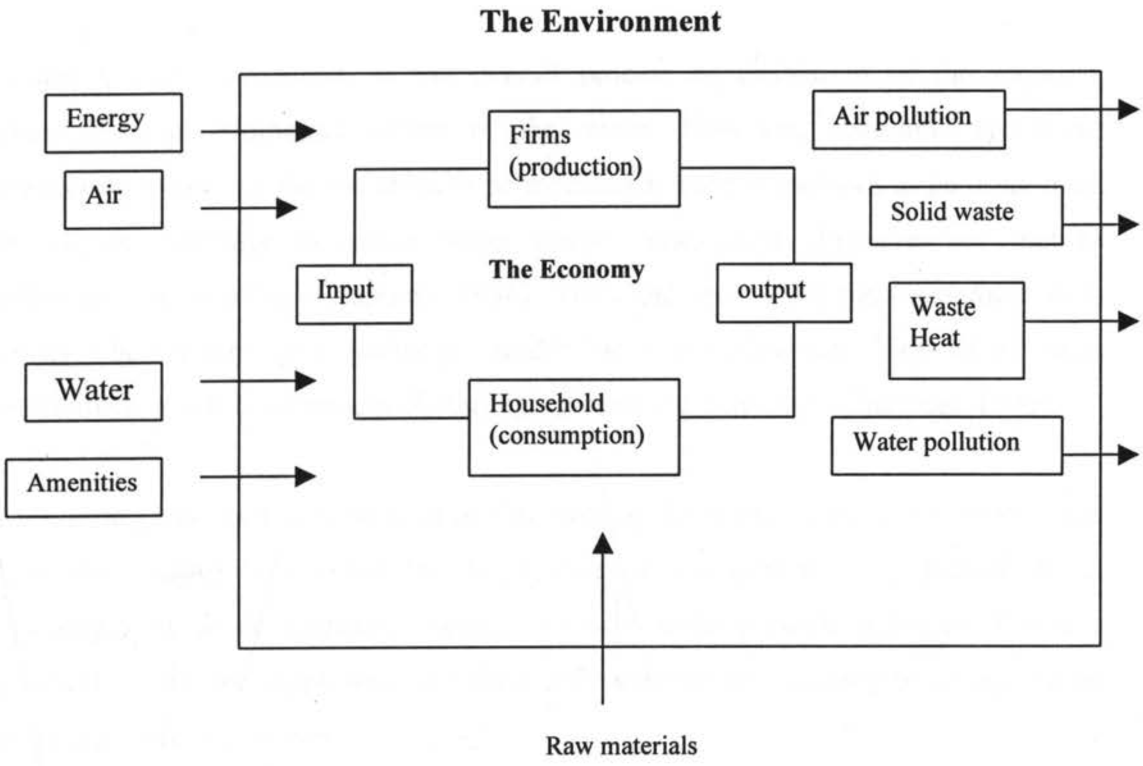


Figure 2.2 : The economic system and the Environment
(source: Tietenberg, 1996)

2.2 Water quality assessment in Malaysia

Water quality assessment, is the overall process of evaluation of the physical, chemical, and biological nature of the water. However, economic constrains frequently mean that the variables to be monitored, and the methods to be used, must be chosen carefully to ensure water quality assessment objectives are met as efficiently as possible (Chapman, 1996). The main reason for the assessment is to verify whether the water quality is suitable for its intended uses. Most of the time, assessment is achieved principally through monitoring activities (Chapman, 1996).

Monitoring has been used to help in determining the trends in the water quality and how the quality is affected by the release of contaminant or pollutant fluxes discharged by waste treatment operation or other anthropogenic activities. The data generates from the monitoring activities are essential for meaningful interpretation and management decision.

The most widely used assessment were the classification schemes and the water quality index system. Classification scheme are based on criteria and standard set-forth specifically for physico-chemical variables and modified by different countries to suit their local requirement. The index system is to relate a group of variables to a common scale, combining them into a single number. The group should ideally contain the most significant parameters of the data set so that the index can describe the overall position and reflect change in a convincing and representative manner. Some information may be lost in the process, but properly designed index the information loss should be of such a nature so as not to cause distortion or misinterpretation of results (Norhayati, 1981). The application of water quality indices and classification system may not only confine to determine the status of water quality, but can also provides an important inputs for the beneficial uses of water as well as in checking the compliance on water quality criteria and standards (Zahit, 2000).

To assist in the dessimination of water quality information to lay-peoples in particular, water quality indices have been developed. Indexes are used in other fields too but they have one thing in common that is they are intended to convey a simple summary of complex data, be it in the field of water quality, air pollution or other field (Smith, 1989).

Water quality monitoring serves a number of purposes, including monitoring for assessment against compliance with national and international standards and commitment arising from international agreements or conventions and for general surveillance serve to detect temporal and spatial differences trends and changes in quality of surface water (Newman *et al.*, 1994).

Regulatory authorities and regulated industries may also have a business or operational need to monitor. This would include the monitoring of discharges to surface water (as part of consent conditions) or as is becoming more acceptable, the self monitoring by those being regulated.

Water quality is a multivariate phenomenon, at least as reflected in the multitude of constituents which are used to characterized the quality of a water body. Such a complex description makes it very difficult to monitor and assess the performance of policies and actions intended to improve the quality of water relative to a variety of uses. Water quality indices have been proposed to serve as metric in this multidimensional space.

Basic to the definition of every water quality index is the choice of a set of constituent which are developed to collectively represent water quality, where quality may be defined with or without respect to a stated use. Indices are said to be basically of three kind:

1. Functions of transformation of variable, where the transformation do not depend, except, perhaps implicitly on standards.

2. Functions of transformation variables, where the transformations depend explicitly on standards which define the suitability of water for a particular use.

3. Functions of the values of the variables themselves without a preliminary transformation steps (Landwehr M.J. 1979).

The first kind, are proposed by Horton (1965); Brown *et.al.,* (1970); Deimingert and Maciunas (1971); Dinius (1972); Barker and Kramer (1972); O'Connor (1972); Mc.Clelland *et.al.*, (1973); Walkis and Parker (1974); the state of Georgia and Dunnettee (1979).

The second category have been proposed by Nemerow and Sumitomo (1970) and Environmental Protecton agency (EPA) (1973) and Stoner (1978). The third category have a wide variety of mathematical structures found in it. These include efforts to formulate indices based on factor analysis (Shoji *et. al.,* 1966; Dronby, 1971), principle component analysis (Rogers, 1971), and Kendall's (1955) multivariate ranking procedure (Harkins, 1974; Shaeffer and Janardan, 1977).

2.2.1 The Malaysian scenario

In Malaysia, an extensive monitoring programmes started in 1985, aiming at protection of the nation's water resources in the long term. The programmes main emphasis is the application of water quality indices in classifying the river system based on Interim National Water Quality Standards (DOE, 1986). Monitoring activity starts with measurement of water samples at specific station usually designated by longitude and latitude of sampling or measurement site (GEMS, 1992 as cited in Zahit, 2000).

The major contributing source of pollution come from agro-based and manufacturing industry, livestock farming and domestic, and land clearing and earthwork. Based on the main polluting sources, the DOE water quality experts have designed a water quality index mathematical formula comprises of six significant water quality variables, which include dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solid (SS) and ammoniacal nitrogen (AN).

The enforcement of water pollution control by the DOE is based on the effluent discharge standards stipulated in the respective regulations under the Malaysian Environmental Quality Act, 1974 (EQA,1974). Effluent discharge are monitored or measured at the outlet of the discharge point.

Despite the fact that the industries may generally complied with the effluent discharge standards, continuing degradation in water quality is being experienced in these watercourses (DOE, 1990).

Since the monitoring started in 1985, the DOE has been applying the DOE-WQI mathematical and the Harkin-WQI statistical formulae for the indexing and classifying the country's river water quality as shown in Figure 2.3 and Table 2.1. These systems are seen to be practically applicable in monitoring the main source of water pollution (DOE,1994). Basically the reports on the status of the country's surface water quality were inform to the Cabinet Ministers whereby a response strategy can be set-up if conditions prevail.

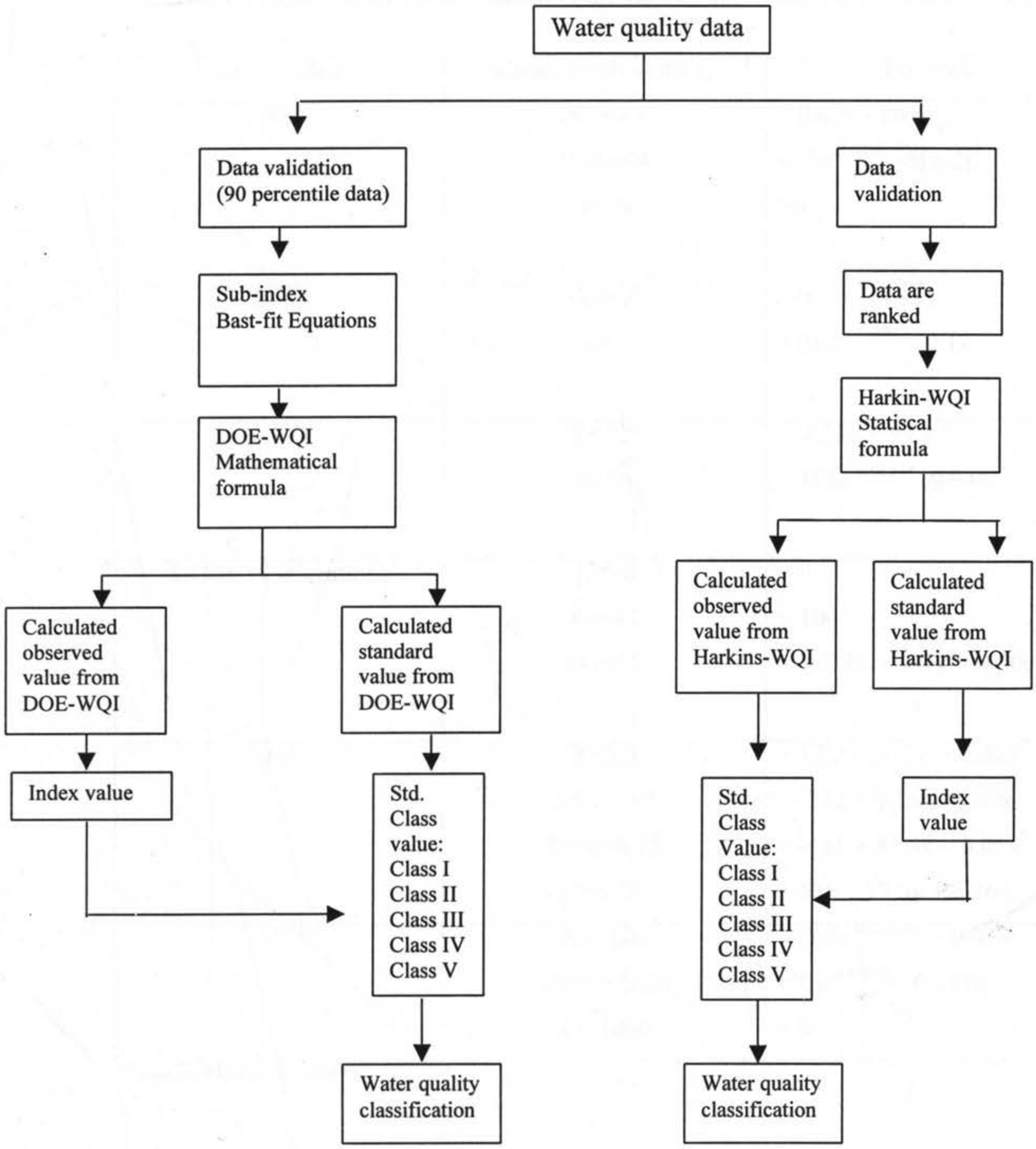


Figure 2.3 : Calculation Process in DOE-WQI and Harkins-WQI technique

Table 2.1 :
Best-Fit Equation for the estimation of the various sub-index values of DOE-WQI

Sub - Index	Concentration (mg/l)	Formula
AN	X<=0.3	$=100.5 - 105x$
	0.3<x<4	$=94e^{-0.573x} - 5[x-2]$
	x>=4	$=0$
BOD	X<=5	$=100.4 - 4.23x$
	x>5	$=108e^{-0.055x} - 0.1x$
COD	X<=20	$=-1.33x + 99.1$
	x>20	$= 103e^{-0.0157x} - 0.04x$
DO(in % saturation)	X<=8	$= 0$
	x>=92	$= 100$
	8<x<92	$= -0.395 + 0.03x^2 - 0.0002x^3$
pH	X<5.5	$= 17.2 - 17.2x + 5.02x^2$
	5.5<=x<7	$= -242 + 95.5x - 6.67x^2$
	7<=x<8.75	$= -181 + 82.4x - 6.05x^2$
	x>=8.75	$= 536 - 77.0x + 2.76x$
SS	X<=100	$=97.5e^{-0.00676x} + 0.05x$
	100<x<1000	$=71e^{-0.0016x} - 0.015x$
	x>=1000	$= 0$

(source: Norhayati, 1981)

2.2.2 Water quality classification scheme

The national water classification scheme and water quality index system normally are based on physico-chemical parameters and the biological parameters being applied separately. A classification scheme comprises of different number of class band. Classification scheme with five bands implies that five classes are used or termed as five-banded scheme (Newman, 1988; DOE, 1990). Each band represents the quality of waters that are based on their criteria and standards of significantly selected parameters.

2.3 Water pollution control

In general the strategy in water quality management can be referred as in Figure 2.4. It begins with setting up of the main objectives of water quality based on the requirement of the respective country in order to provide greater protection to surface water.

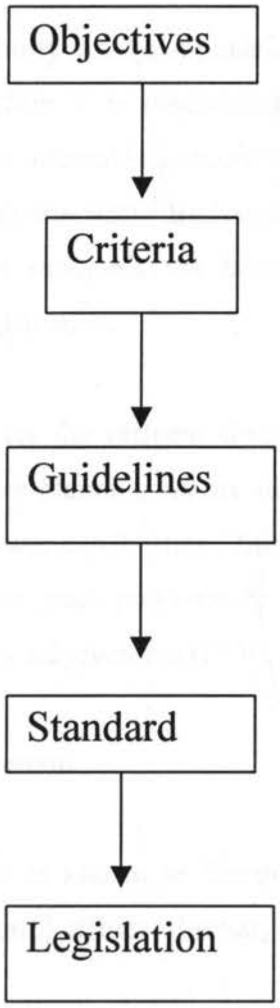


Figure 2.4: Strategy set-up in water quality management (source: Thann and Tam, 1990; Viesman *et.al.*, 1998 as cited in Zahit, 2000)

The objectives, criteria and guidelines do not have any legal status that provides enforcement activity to ensure that the river water quality is not polluted and maintained at desired concentrations. Standards on the other hands are designed to give legal requirement and supports. Thus standards are stated in numerical terms that must be met or violated. In general, standards are based on basic requirement such as:

- Standards based on technology
- Standards based on discharges of effluent
- Standards based on the receiving stream

Standard based on technology capability are the application of the best technology for reducing the harmful pollutant before it is discharged into the water body. The effluent standards are the minimum allowable concentrations for potential pollutant measure at the discharge point where the waste discharge starts entering the receiving water body. The receiving stream standards are based on the capability of the receiving stream to undergo self-purification.

In Malaysia, standards are based on the effluent discharges. The critical process requires a careful balance with other planning inputs such as economic factors, the existing technology and the manpower capabilities (Zahit, 2000). If too high or too low standards were set, it will cause great problems to comply with and will exert some negative impacts on economics achievement (DOE, 1990).

2.3.1 Legislation on Pollution Control

The environmental law in Malaysia is known as Environmental Quality Act 1974, introduced several regulations to control effluent discharge :

- Environmental Quality (Prescribed Premises)(Crude Palm Oil) Regulation 1977 and Amended in 1982 (Table 2.2)
- Environmental Quality (Prescribed Premises)(Raw Natural Rubber) Regulation 1978 and Amended in 1981 (Table 2.3 and 2.4)
- Environmental Quality (Sewage and Industrial Effluents) Regulation 1979 (Table 2.5)

Table 2.2 Malaysia : Palm Oil Mill Wastewater Standards

Parameter	Standard A 1.7.78	Standard B 1.7.79	Standard C 1.7.80	Standard D 1.7.81	Standard E 1.7.82	Standard F 1.7.84
BOD, 3-day. 30°C; mg/l	5,000	2,000	1,000	500	250	100(50*)
COD; mg/l	10,000	4,000	2,000	1,000	-	-
Total Solids; mg/l	4,000	2,500	2,000	1,500	-	-
Suspended Solids; mg/l	1,200	800	600	400	400	400
Oil and grease; mg/l	150	100	75	50	50	50
Ammoniacal Nitrogen; mg/l	25	15	15	10	150**	100**
Organic Nitrogen; mg/l	200	100	75	50	-	-
Total Nitrogen; mg/l	-	-	-	-	300**	200**
PH	5.0-9.0	5.0-9.0	5.0-9.0	5.0-9.0	5.0-9.0	5.0-9.0
Temperature; °C	45	45	45	45	45	45

* This additional limit is the arithmetic mean value determined on the basis of minimum of four samples taken at least once a week for four weeks consecutively

** Value on filtered sample

(source : Zulkifli, 1989)

Table 2.3 Malaysia : Latex Concentrate Wastewater Standard

Parameter	1st.generation standards effective on 1.4.80	2nd generation standards effective on 1.4.81	3rd. generation standards effective on 1.4.82	4th generation standards effective on 1.4.83 and thereafter
pH	6-9	6-9	6-9	6-9
BOD, 3-day. 30oC,mg/l	450	300	200	100(50*)
COD; mg/l	1,500	1,000	500	300
Total solids; mg/l	2,500	2,000	1,000	-
Suspended Solids; mg/l	1,000	800	250	150(100**)
Total Nitrogen, mg/l	450	350	350	300(60**)
Ammoniacal Nitrogen; mg/l	350	300	300	300(40**)

* this additional limit is the arithmetic mean value determined on the basis of minimum of four samples taken at least once a week for four weeks consecutively

** as the target limit to be achieved as soon as possible in accordance with RRIM's recommendation on research.

(source : Zulkifli, 1989)

Table 2.4 Malaysia : SMR Block Rubber Wastewater Standards

Parameter	1st generation standards effective on 1.4.78	2nd generation standards effective on 1.4.79	3rd generation standards effective on 1.4.80	4th generation standards effective on 1.4.81 and thereafter
pH	6.0-8.0	6.0-8.0	6.0-8.0	6.0-8.0
BOD, 3-day. 30oC; mg/l	500	300	200	100(50*)
COD; mg/l	1,000	750	500	250
Total Solids; mg/l	1,000	1,000	1,000	-
Suspended Solids; mg/l	250	250	250	150(100**)
Total Nitrogen; mg/l	100	100	100	60**
Ammoniacal Nitrogen; mg/l	800	70	70	40**

* this additional limits is the arithmetic mean value determined on the basis of minimum of four samples taken at least once a week for four weeks consecutively.

** value on filtered sample in accordance with RRIM's recommendation based on research

(source : Zulkifli, 1989)

The standards in the tables above involving sets of standards generation that must be achieved within the targeted year. Table 2.5 consists of two set of parameter limits for the sewage and industrial effluent to comply with. Standard A are limits for effluent discharge into water courses upstream of public water supply intake point, while Standard B is for effluent discharge into water courses downstream of public water intake point. Apart from the two Standards there are provision in the regulation which empowers the Director General of Environment to specify the acceptable conditions of discharge including parameter limits of effluent with respect to any or all of the parameters. Section 25(1) of the EQA allows for contravention of the parameter limits under acceptable conditions.

Table 2.5 Malaysia : Parameter Limits of Effluent of Standards A and B

THIRD SCHEDULE
ENVIRONMENTAL QUALITY(SEWAGE AND INDUSTRIAL EFFLUENTS)REGULATION,1979
Regulation 8(1), 8(2), 8(3)

	Parameter	Unit	Standards A	Standards B
	(1)	(2)	(3)	(4)
(i)	Temperature	°C	40	40
(ii)	pH value	-	6.0-9.0	5.5-9.0
(iii)	BOD_5 at 20° C	mg/l	20	50
(iv)	COD	mg/l	50	100
(v)	Suspended Solids	mg/l	50	100
(vi)	Mercury	mg/l	0.005	0.05
(vii)	Cadmium	mg/l	0.01	0.02
(viii)	Chromium, Hexavalent	mg/l	0.05	0.05
(ix)	Arsenic	mg/l	0.05	0.10
(x)	Cynide	mg/l	0.05	0.10
(xi)	Lead	mg/l	0.10	0.50
(xii)	Chromium, Trivalent	mg/l	0.20	1.0
(xiii)	Copper	mg/l	0.20	1.0
(xiv)	Mangenese	mg/l	0.20	1.0
(xv)	Nickel	mg/l	0.20	1.0
(xvi)	Tin	mg/l	0.20	1.0
(xvii)	Zinc	mg/l	1.0	1.0
(xviii)	Boron	mg/l	1.0	4.0
(xix)	Iron (Fe)	mg/l	1.0	5.0
(xx)	Phenol	mg/l	0.001	1.0
(xxi)	Free Chlorine	mg/l	1.0	2.0
(xxii)	Sulphide	mg/l	0.50	0.50
(xxiii)	Oil & Grease	mg/l	ND	10.0

Note: ND – Not Detected
(source : Zulkifli, 1989)

CHAPTER THREE

METHODOLOGY

3.1 Study Area

Malacca River Basin is the main river in the state of Malacca with the upper reaches of the river extending into the state of Negeri Sembilan. The river basin covers a total area of approximately 600 sq. km. Figure 3.1 shows the main tributaries , the water quality monitoring stations and the main physical structures such as flow gauging station, water intake, diversion structure and tidal barrages. More than 70% of the water supplied to the state of Malacca originates from the river at the Durian Tunggal water intake. The upstream of the water intake, the catchment area currently features three important point source of such pollution: Tampin in Negeri Sembilan and Alor Gajah town and industrial estate in Malacca. The distance from the water intake to Tampin is about 25 km and 12 km to Alor Gajah. A number of pollution parameters exceeds the recommended limits in the Malaysian Interim Standards for Water Quality, relating to water intake for public supply with conventional treatment.

3.2 River water quality

3.2.1 Data Collection for the computation of Water Quality Index (WQI)

The water quality of the river is regularly monitored at 11 monitoring stations. The location of the catchment area and sampling stations are shown in Figure 3.1. Grab samples were taken within the range of 4 times per year. The water quality parameters measured are:

In-situ parameter: pH, temperature, dissolved oxygen, conductivity Laboratory analysis: Biochemical Oxygen Demand (BOD), Chemical oxygen demand (COD), Ammoniacal Nitrogen (NH_3-N), suspended solid (SS), heavy metals and others.

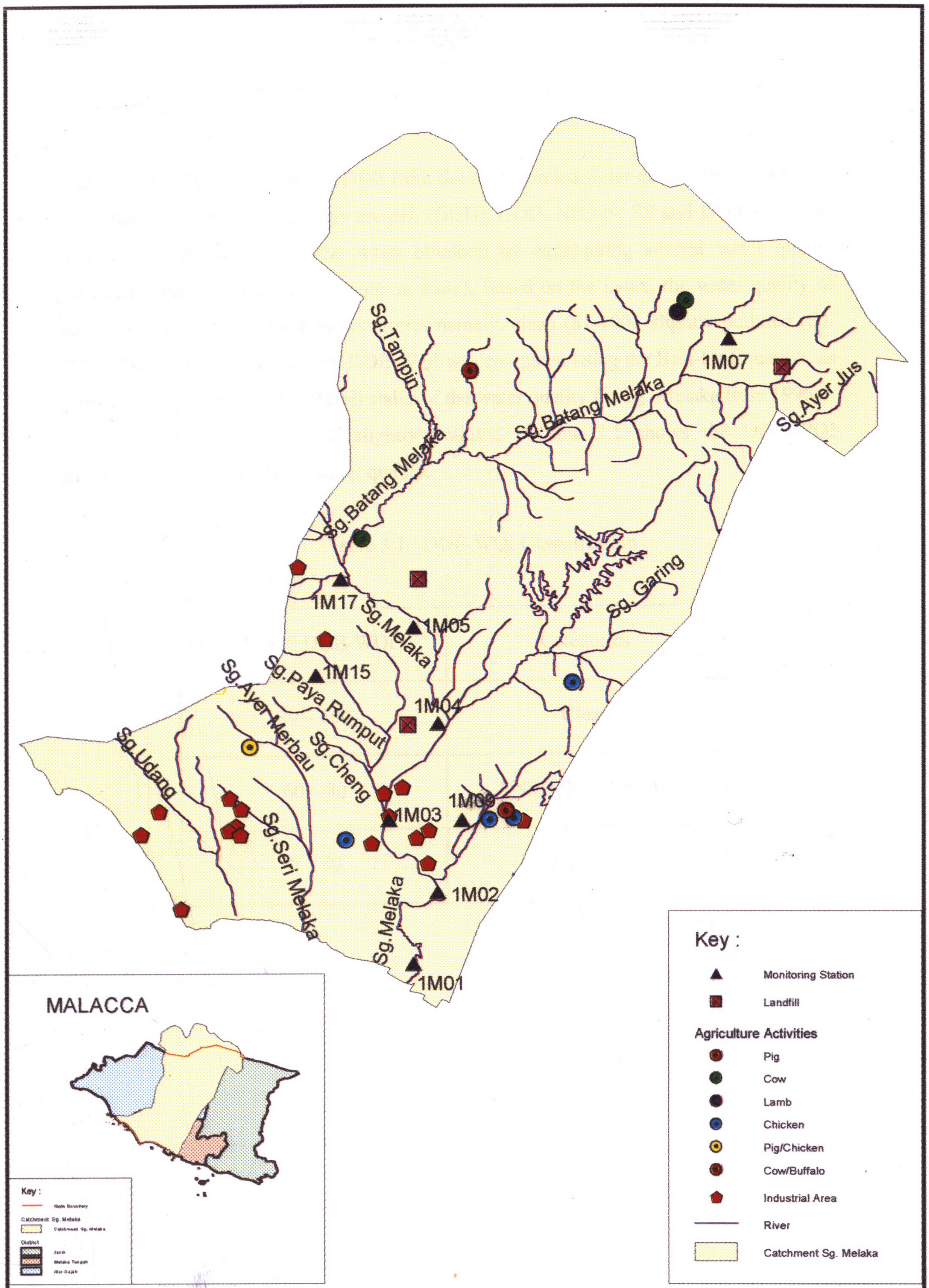


Figure 3.1 CATCHMENT OF SUNGAI MELAKA

3.2.2 Water quality status

The water quality is assessed by DOE from the compounded water quality Index, WQI (0-100), the determining parameters are pH, (BOD), COD, NH3-N, SS and DO. WQI is an indicator of the quality of the water obtained by aggregating several water quality parameters into one number (a common scale). Based on the index, the water quality of the river is classified into three categories namely, clean (81-100), slightly polluted (60-80) and severely polluted (0-59). DOE-WQI was computed using the Best-Fit Equation, as shown in Chapter two. The overall status of the water quality for Sg. Melaka from 1996 to 2000 was in the category of slightly polluted. Table 3.1 shows the DOE-WQI classification on the status of water quality.

Table 3.1 : DOE-WQI Classification

Overall DOE-WQI	Categories
80 – 100	Clean
60 – 80	Slightly Polluted
0 – 59	Polluted

Seven monitoring stations were selected to the discharge from 10 industrial sites located within the catchment of Sg. Melaka as shown in Figure 3.2. There are as listed in Table 3.2. All data computed for the WQI are shown in Appendix A.

Table 3.2 : Monitoring Station for Various Industrial Estate in Malacca

Industrial Estate	Station No.
Alor Gajah	2322610
Cheng	
Krubong	2322605
Malim Jaya	
Batu (Bt.) Berendam	2322603
Bt. Berendam FTZ	
Taman Tasek	
Ayer Keroh	2322604
During Tunggal	2322607
Tebong	2322614

3.3 Compliance Data

3.3.1 Data collection for compliance of EQA

The effectiveness of the EQA are measured through the number of various industry complying to the sections 18,19, 20, 21, and 25 in the EQA as well as to the standards set in the regulations made under the act. The regulation pertaining to water pollution made under the act are as mentioned in Chapter two. The method in which the compliance data are complied were through :

- Self monitoring report from industries
- routine visit to the industries
- ‘spot check’
- complaint from public

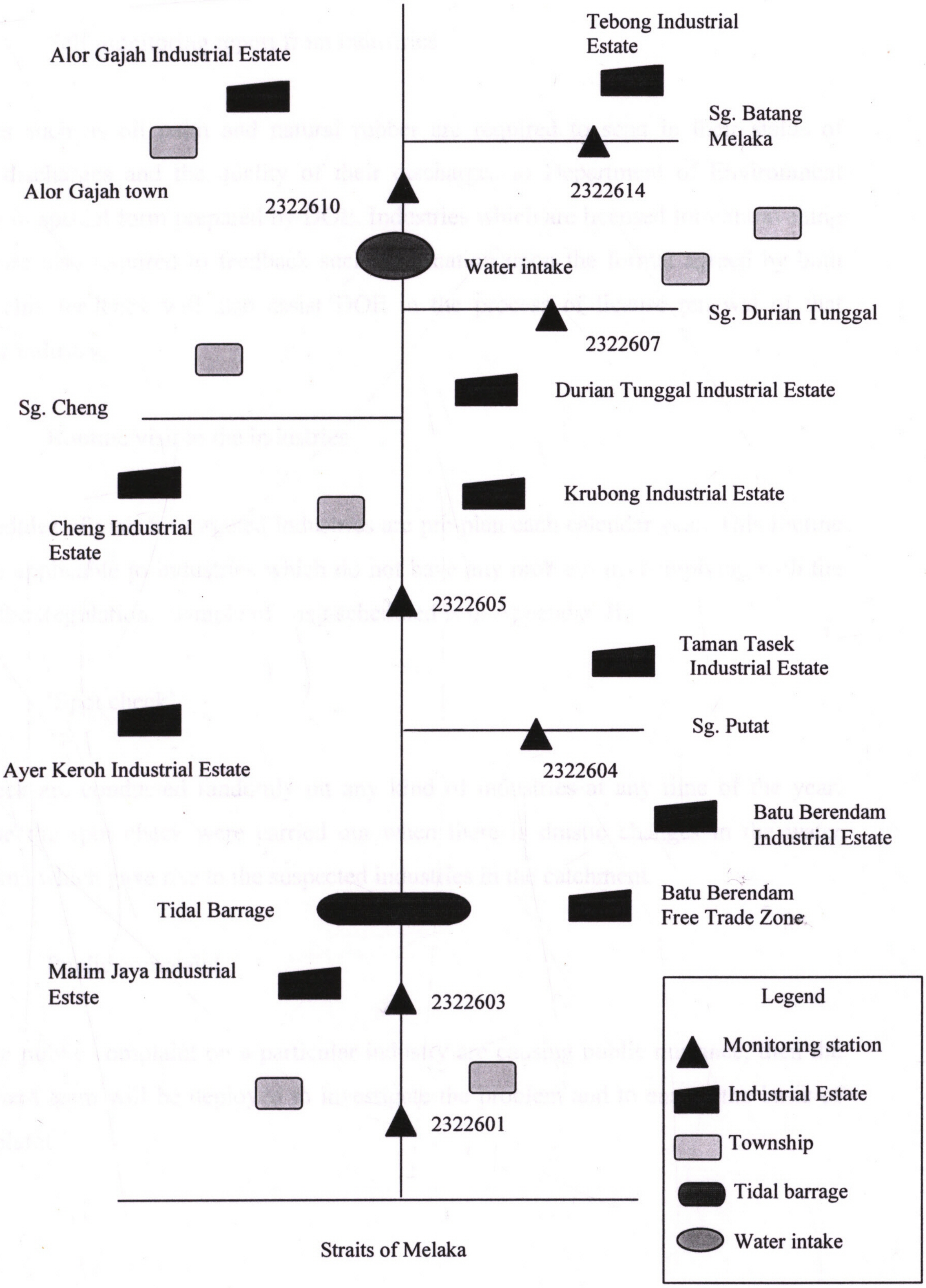


Figure 3.2 : Schematic Diagram of Sg. Melaka Catchment

3.3.1.1 Self monitoring report from industries

Industries such as oil palm and natural rubber are required to send in their status of effluent discharges and the quality of their discharges to Department of Environment quarterly in special form prepared by DOE. Industries which are licensed for contravening the Act are also required to feedback such information upon the format agreed by both parties. This feedback will also assist DOE in the process of license renewal of that particular industry.

3.3.1.2 Routine visit to the industries

The schedules of visit for targeted industries are pre-plan each calendar year. This routine visits are applicable to industries which do not have any problem in complying with the Act and the Regulation. Sample of visit scheduled is in Appendix B.

3.3.1.3 'Spot check'

Spot check are conducted randomly on any kind of industries at any time of the year. Sometime the spot check were carried out when there is drastic changes in the water quality data which gave rise to the suspected industries in the catchment.

3.3.1.4 Public complaint

When the public complaint on a particular industry are causing public nuisance, then the enforcement team will be deployed to investigate the problem and to ensure the basis of the complaint.

3.3.1.5 Types of pollution source

- Domestic waste water
- Industrial wastewater
- Livestock
- Agricultural activity
- Construction sites runoff
- Accidental spill
- Domestic solid waste
- River sediments

Only the loading from industrial estate will be taken into account as the number of compliance are based on the visit to the industries within the industrial estate. Other sources of pollution are consider to be non-point source and are generally difficult to enforce the EQA.

All data on compliance to EQA are shown in Appendix C.

3.4 Data Analysis

Least squares method was employed to develop the trend by a definable mathematical function as well as data modeling using least square method with the aid of CURFIT. Using this technique the data set for every location was condensed by fitting it to a model in the form of parametric equation. The model equation ranged from a simple polynomial to an extremely complex model. This procedure involved various family models of which include exponential, power, growth, yield-density and miscellaneous. Data modeling were performed by regression techniques. Every possible regression model was examined for a data set. As curve fits are applied, a ranking chart keeps track of the best to the worst models. Error is assessed using the standard error and correlation coefficient of which measured the goodness of fit. As the regression model described the data, the correlation coefficient will approach unity. For a perfect fit, the standard error of the estimate will approach $S = 0$ and correlation coefficient will approach $r = 1$ (Rosni, 2000). Data for the computation of curve fits is as shown in Appendix D.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 No Relationship Observation

The table below summarizes the result from the data analysis (Figure 4.1 to 4.30):-

Table 4.1: Stations of non-relationship

No.	Stations Number	Names of Industrial Estate	Standards Complied	Number of Industries	Type of Industries
1.	2322614	Tebong	A	1	Natural Rubber
2.	2322607	Durian Tunggal	B	1 1	Natural Rubber Rubber Based
3.	2322605	Krubong	B	1	Paper Based
4.	2322604	Taman Tasek	B	1 1	Beverage Paper-Based
5.	2322603	Bt. Berendam	B	1	Food
6.	2322603	Malim Jaya	B	4	Metal Based
7.	2322603	Bt. Berendam Free Trade Zone	B	1 14	Paper-Based Electronic

Six out of seven industrial estates of non-relationship have small number of industries operating in it. Tebong Industrial Estate being upstream of water intake point have to comply to Standard A. Tebong is located on the upper catchment of Sg. Melaka, towards the border states between Melaka and Negeri Sembilan. The DOE-WQI for station 2322614 which was design to monitor the Tebong Industrial Estate was between 70-80 which is in the category of slightly polluted according to DOE classification. But the compliance of the particular industry was 100% through out the 5 years. Ideally if the compliance of the industry was 100% the river water quality should be in the clean category (DOE WQI of 80 and above). The reason for this phenomena could be either more than 50% of the time the industry was violating/not complying to the standard or the source of the pollution at station 2322614 may be largely due to contribution from the non-polluted sources, which could not be quantifiable. (Figure 4.1 to 4.3).

Batu Berendam free trade zone was abnormal, having large number of industries but statistically no relationship (Figure 4.3 to 4.5). The profile of this industrial estate is that, it has more electronic-based industries (14 out of 15) as compared to the paper based industries. The reasons for the non relationship could be due to the parameters in determining the DOE-WQI. As electronic industries are well known to produce more heavy metal contaminants than any other industries, it is of priority to consider this parameter as a determinant for the status of water quality. The DOE-WQI of this station was below 60, so the contribution from the non-point source cannot be ruled out. Perhaps most of the time, the status of water quality determined by DOE-WQI was measuring the non-pollutants source contribution. From the graph (Figures 4.4 and 4.5) COD, pH, seems to show same indication, perhaps with more data, the relationship can be established as COD and pH are surrogate parameters to indicate pollution from non-organic contaminant.

The other non-relationship (Figures 4.6 to 4.21) shows DOE-WQI cannot be used to determine the effectiveness of EQA, because the 2 variables does not vary with each other. Thus the % compliance indicates nothing about water quality as to whether the 100% compliance will improve the water quality status or not. The pecularity for such behaviour could be due to several reasons; small number of industries are less visited by DOE enforcement team, thus unable to capture the non-compliance event, so the compliance of the industries are based on one or two visit which explain why the compliance is 100%. Relying on self-monitoring report must be exercised with great precautionary measure and triggering mechanism must be developed as to the reliability of the report submitted. Increasing the frequency the sampling could assist in capturing the non-compliance event and hence pinning down the suspected industry. A particular industry such as natural rubber or rubber-based has its own effluent characteristic that prevails in the analysis of the water quality. Being a small industrial estate, with one or two industries operating in it, the culprit can be easily determine or any abnormally in the operation can be easily detectable through the anlysis of water sample. There are tendency by industries not to inform the authority if they have increase in their production capacity or change their process, until and unless visited by the enforcement officer, especially industries which are less visited. Such event will contribute to the non-compliance event not detected. Thus the statistic of the compliance event remain unchanged.

Sampling should not only be confined to authority working hour, it should be distributed within the 24 hours especially industries which are working with 3 shifts per day. Having treatment facilities is an additional cost to the industries, whenever cost saving is to be implemented it will be at the expense of the environment, in this case the water quality. The time interval in scheduling of the sampling must coincide with working hours of the industries concerned so as not to miss any non-compliance event, perhaps an automatic sampling station could compliment the manpower resources of DOE.

The location of sampling station should be chosen in such a way that it does not overlap/or measuring too many sources. As for example the station 2322603 measures 3 industrial estates, station 2322604 and 2322605 measures 2 industrial estates each. Complication will arise in determining which industries is the main sources of the pollution of the river, especially where most of the industries operating in that particular industrial estate are of the same type and/or process of the same nature. Being unable to segregate the unknown sources will create a lot of uncertainty to the interpretation of the data analyse.

Acknowledging the difficulty in designing the sampling station, frequent reviewing of the sampling location is crucial due to the dynamic changes in land-use pattern of the Sg. Melaka catchment, being one of the most important catchment in Melaka providing water supply to the state of Melaka, is certainly facing a conflict in maintaining the catchment for water supply as well as for development purposes.

Bearing in mind, that EQA was mainly design targetting the point sources, and the standard set are mainly for discharging purposes, and not meant to gauge the ambient level, the best alternative to compare the ambient level will be the proposed Interim National Water Quality Criteria and Standard. As it guide the concerned authority to management plan accordingly to the intended usage of the river.

4.2 Relationship Observed

Guilford provides a guide in the interpretation of the strength of relationship between two variables. The guide is known as Guilford's rule of thumb. (Table 4.2).

Table 4.2 : Guildford's Rule of Thumb

Correlation Coefficient	Strength of Relationship
< 0.02	Almost negligible relationship.
0.20 – 0.40	Low correlation; definite but small relationship.
0.4 – 0.7	Moderate correlation; substantial relationship.
0.7 – 0.9	High correlation; marked relationship.
> 0.9	Very high correlation; very dependable relationship.

(Source : Guilford, J.P. 1956, as Cited in Bahaman et.al.; 1999).

A positive r indicates a positive correlation, a negative indicates a negative correlation while a zero indicate no correlation. The plus and minus implies the direction of the relationship.

Table 4.3 : Summary of Data Analysis

Industrial Estate : Alor Gajah (Station No. 2322610)

No. of Industries : 16

Types of Industries : Food-based (3), Rubber-based (4), Paper-based (4), Metal-based (4) and Electronic (1)

Parameter	R	Strength of r	S
DO	0.9337	Very high correlation very dependable relationship.	2.6925
BOD	0.9520	Very high correlation very dependable relationship.	2.2360
COD	0.9488	Very high correlation very dependable relationship.	4.7169
AN	0.7355	High correlation, marked relationship.	9.4622
SS	0.0246	Low correlation, definite but small relationship.	6.7012
pH	0.1847	Low correlation, definite but small relationship.	1.2431
Overall DOE-WQI	0.8875	High correlation, marked relationship.	1.5500

For discharges from Alor Gajah industrial estate, the water quality sampling station is at station 2322610. This station is situated in the upper catchment of Sungai Melaka. Four out of six parameters measuring the index of the water quality are highly corelated, i.e. DO, BOD, COD and AN. Whilst SS and pH have very low correlation. BOD, COD, SS, pH, have 2 set of standard stipulated in the Sewage and Industrial Regulation (Refer Chapter 2) except DO, and AN. Alor Gajah Industrial Estate being located above the water intake points is required to meet Standard A which is comparatively very stringent standard to be met. The fact that DO is highly correlated to the compliance is explainatory due to the compliance of the other (3) parameters, despite the oxygen being consume in the decay process the D.O resume it concentrating considerably fast. Thus for Alor Gajah Industrial Estate, this 4 parameters are suitable for determinant in determining the status of compliance. The overall DOE-WQI also indicate the same trend. (Figures 4.22 to 4.24).

As for SS and pH, which have very low relationship are not suitable as determinants, but if it use were to be collectively in the overall DOE-WQI, strong correlation prevails. For Alor Gajah Industrial Estate, the water quality status (determined by DOE-WQI) can be used to determine the effectiveness of EQA, and DO, BOD, COD, AN are the group of parameters that highly correlated to the compliance.

Table 4.4 : Summary of Data Analysis

Industrial Estate	:	Ayer Keroh (Station No. 2322604)
No. of Industries	:	15
Types of Industries	:	Food-based (5), Rubber-based (3), Iron Work (1), Plastic-based (1), Paper-based (3), Textile (2)

Parameter	R	Strength of r	S
DO	0.6902	Moderate correlation; substantial relationship.	14.6701
BOD	0.6550	Moderate correlation; substantial relationship.	10.2192
COD	0.8801	High correlation, marked relationship.	6.3995
AN	0.7457	High correlation, marked relationship.	8.1435
SS	0.7526	High correlation, marked relationship.	7.3433
pH	0.9987	Very high correlation; very dependable relationship.	1.4142
Overall DOE-WQI	0.9707	Very high correlation; very dependable relationship.	2.8284

All the parameters in station 2322604 have substantial relationship with the compliance status. And the overall correlation is very high. Station 2322604 located on Sungai Putat the only station that is not located on the mainstream i.e. Sungai Melaka (Refer Figure 1). Ayer Keroh has 15 industries within it, discharging into Sungai Putat complying to Standard B. This station is the best model of correlating water quality to compliance if only the contribution for the non-point source can be eliminate. Location wise, it is strategically located to capture the effluent for the Ayer Keroh Industrial Estate as compared to other station. Figure 4.25 to 4.27 shows all the parameters exhibit different pattern which means they behave independently of each other except for pH and the overall DOE-WQI, the pattern are identical. Although DO show substantial relationship but the standard error is quite large. Thus the r value maybe misleading.

Table 4.5 : Summary of Data Analysis

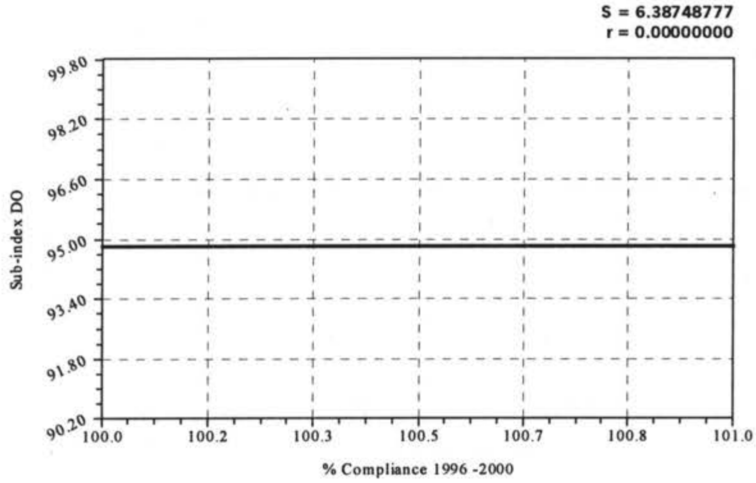
Industrial Estate : Cheng (Station No. 2322605)
No. of Industries : 9
Types of Industries : Electronic (3), Paper-based (2), Pharmaceutical (3), Food-based (1)

Parameter	R	Strength of r	S
DO	0.0294	Low correlation; definite but small relationship.	13.1497
BOD	0.8188	High correlation, marked relationship.	2.9860
COD	0.8760	High correlation, marked relationship.	5.1881
AN	0.6489	Moderate correlation; substantial relationship.	9.5350
SS	0.8428	High correlation, marked relationship.	9.3985
pH	0.43133	Moderate correlation; substantial relationship.	2.1602
Overall DOE-WQI	0.43133	Moderate correlation; substantial relationship.	2.1602

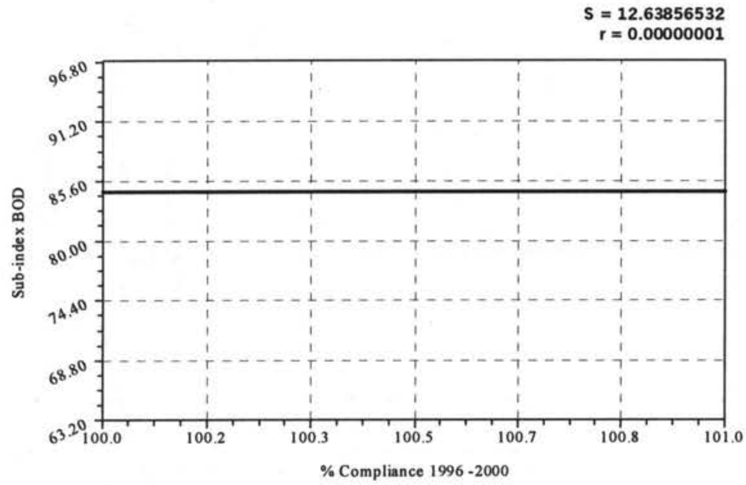
Station 2322605 which is supposed to be measuring Cheng's Industrial Estate discharges are located just outskirt of Melaka town, that means station 2322605 is downstream of the Melaka Catchment. Being downstream station 2322605 not only capture discharges from the Cheng's Industrial Estate, it also measures pollutant input from other sources. The overall relationship does not show a very strong relationship, although five out of six parameters used to calculate the DOE-WQI shows a substantial relationship. The interference from other sources could be the reasons for this behaviour. (Figures 4.28 to 4.30).

Analysing the graphs drawn for the 3 industrial estates, it seems that parameters which are highly correlated, influences the overall DOE-WQI pattern. As in Alor Gajah, the shape of graph for DO, BOD and COD are identical to the overall DOE-WQI in Cheng Industrial Estate all are line only fit except for DOE this further strength the assumption that CO does not has any influence or compliance and Air Keroh Industrial Estate the overall DOE-WQI is strongly influenced by pH.

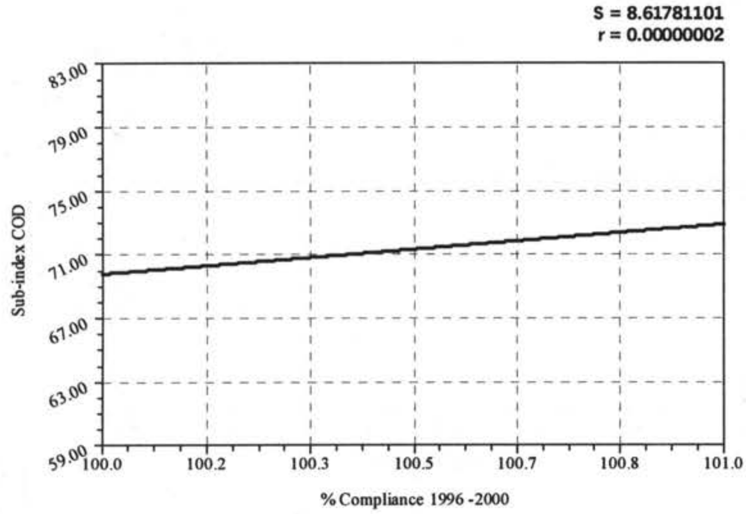
From the data analysis, DO shows very low correlation in relation to other parameters. Comparing the result in Alor Gajah, DO have a very high correlation. DO is a function of aeration and the ability of the river to purify/recover it self explain the variability of the r value for each industrial estate. Thus in case of Alor Gajah, the station is located upstream, and the industrial discharge are complying to standard A which means that the river was able to recover faster and higher rate of aeration, increases the concentration of DO. This does not happen in station 2322605 due to excess pollutant loading into the rivers, and being at the downstream will has an influence disadvantage because other sources of pollution which contribute to high loading. SS and pH have very substantial relationship at station 2322605 as compared to station 2322610. The reason of such relationship in pH and SS could be due to high loading and contribution from non-point source or indiscriminate source.



Weibull Model: y=a-b*exp(-c*x^d)
Coefficient Data:
a = 108.9032
b = 36.0918
c = 1.009526
d = -0.01557

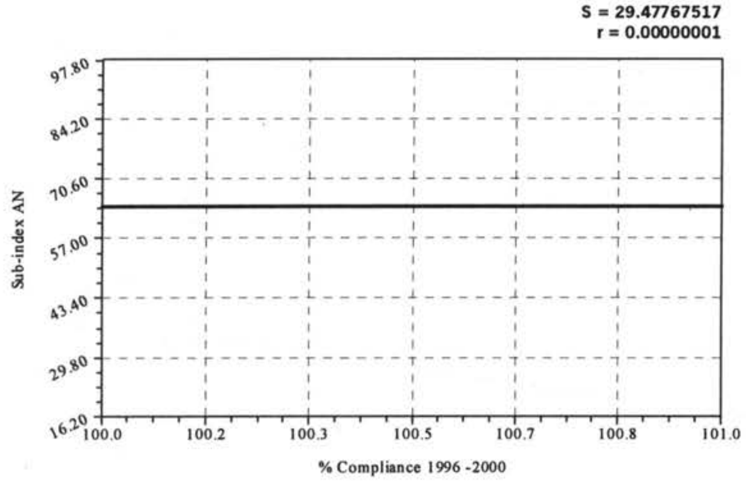


Geometric Fit: y=ax^(bx)
Coefficient Data:
a = 84.28591
b = 8.08E-06

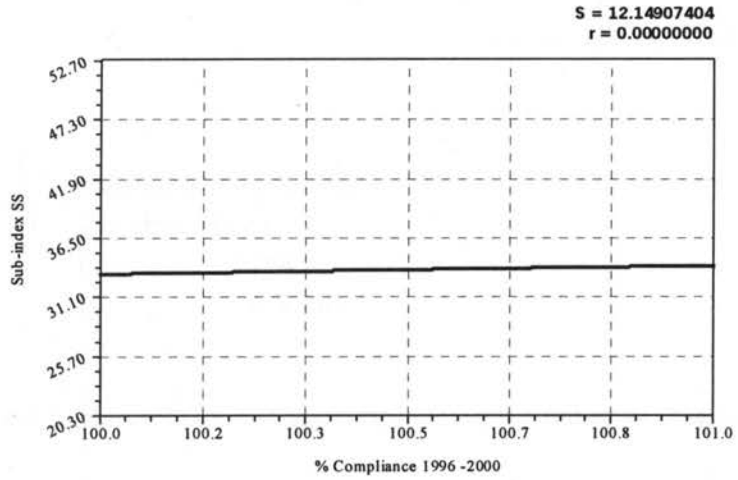


Geometric Fit: y=ax^(bx)
Coefficient Data:
a = 1.907135
b = 0.007817

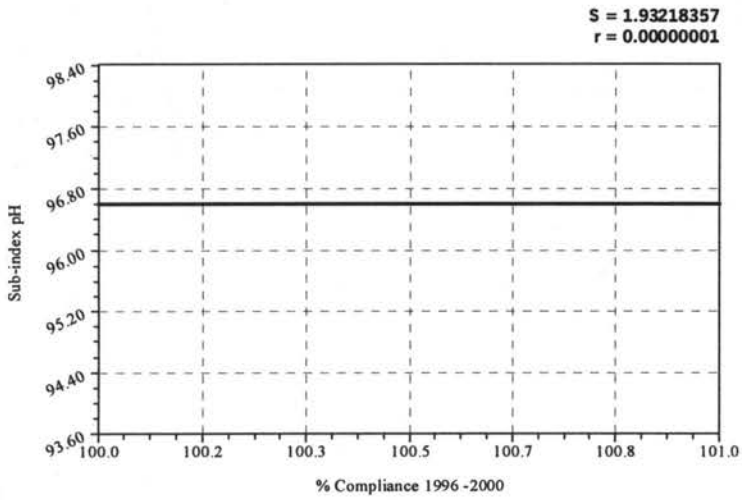
Figure 4.1 : Percent Compliance Tebong Industrial Estate vs Sub-index Station 2322614, 1996-2000



Modified Geometric Fit: a*x^(b/x)
Coefficient Data:
a = 61.18631
b = 1.044039

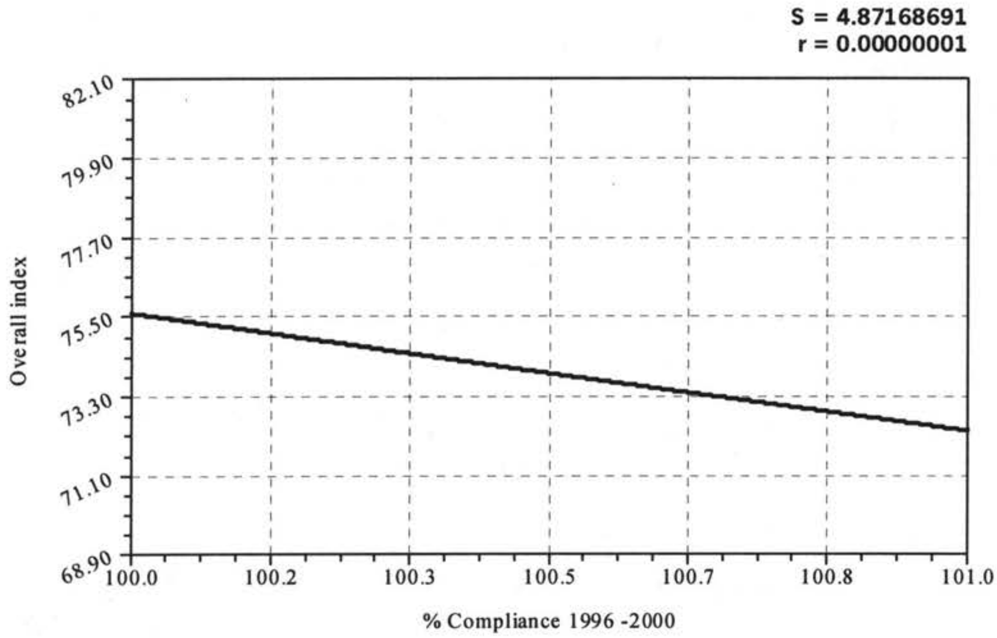


Geometric Fit: y=ax^(bx)
Coefficient Data:
a = 5.393008
b = 0.003947



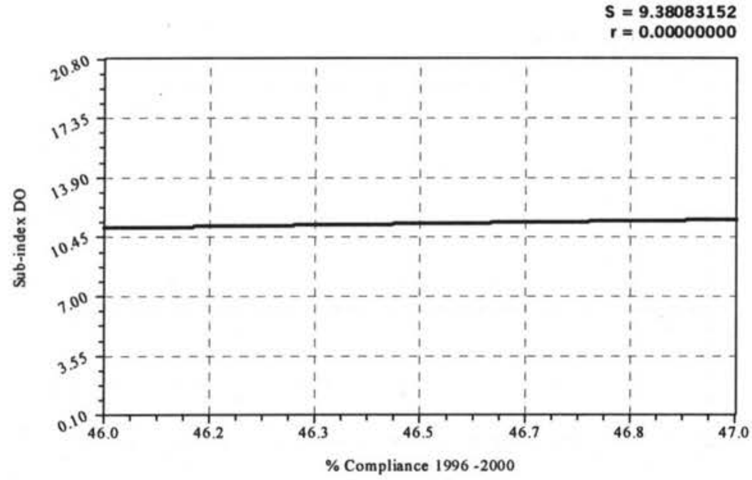
Modified Geometric Fit: a*x^(b/x)
Coefficient Data:
a = 96.59416
b = 0.001313

Figure 4.2: Percent Compliance Tebong Industrial Estate vs Sub-index Station 2322614, 1996-2000



Geometric Fit: y=ax^(bx)
Coefficient Data:
a = 2758.987
b = -0.00781

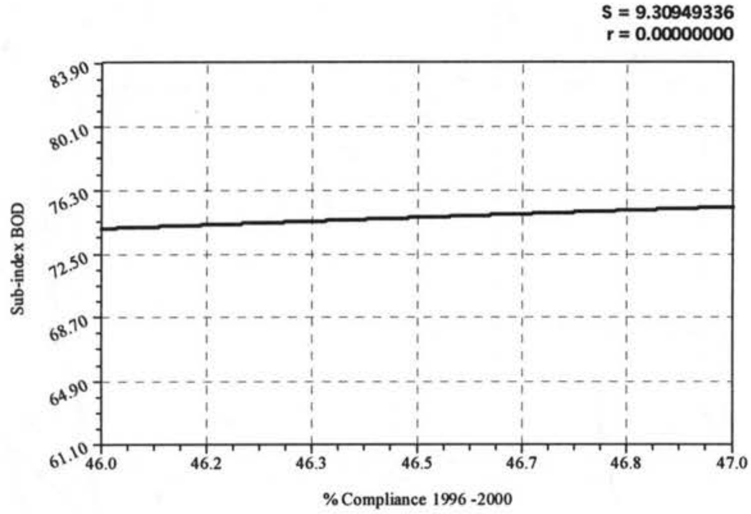
Figure 4.3 : Percent Compliance Tebong Industrial Estate vs Overall index Station 2322614, 1996-2000



Geometric Fit: y=ax^(bx)
Coefficient Data:

a = 2.220917

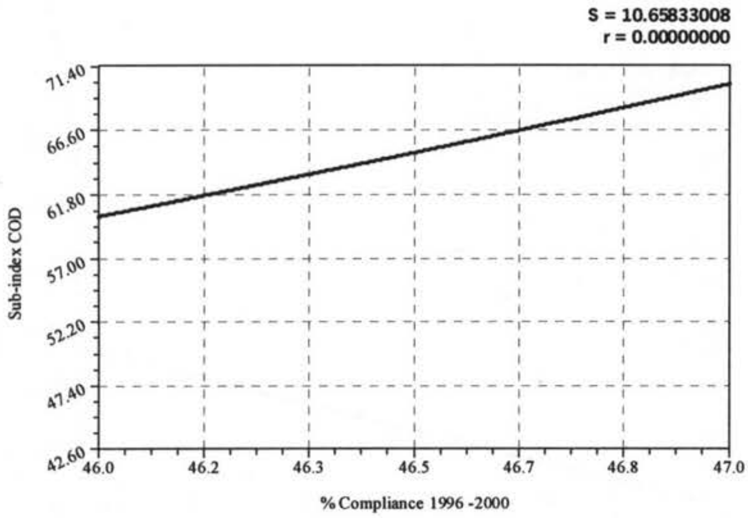
b = 0.009085



User-Defined Model:
y=a+b*x
Coefficient Data:

a = 14.5

b = 1.293478

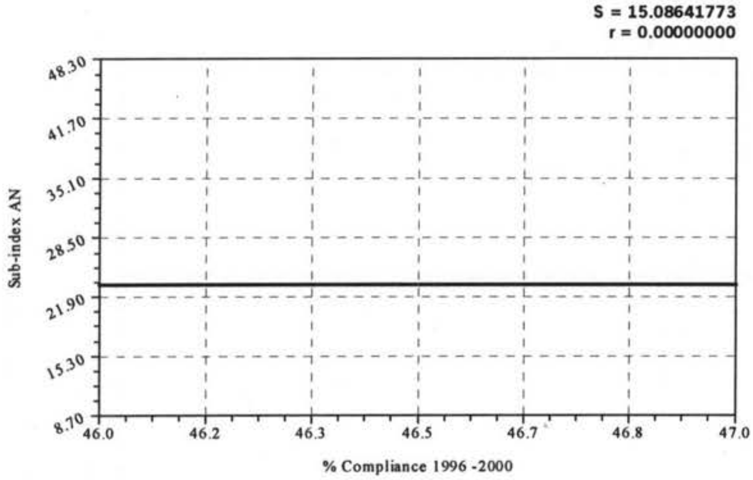


Geometric Fit: y=ax^(bx)
Coefficient Data:

a = 0.243836

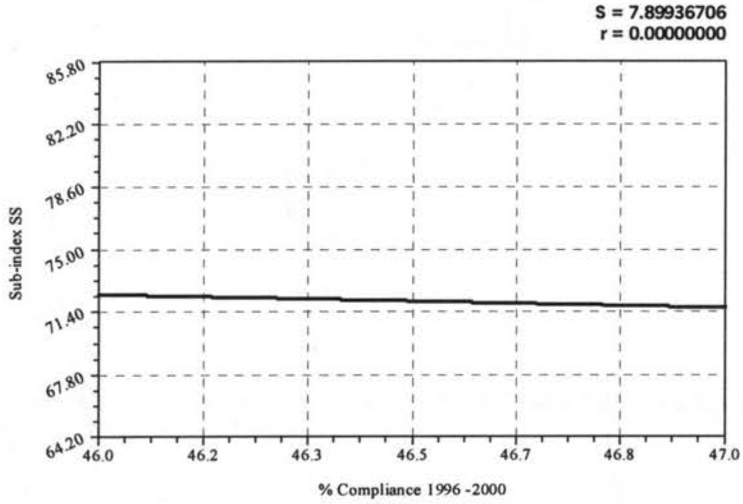
b = 0.03128

Figure 4.4 : Percent Compliance Bt. Berendam (Free Trade Zone) vs Sub-index Station 2322603, 1996-2000



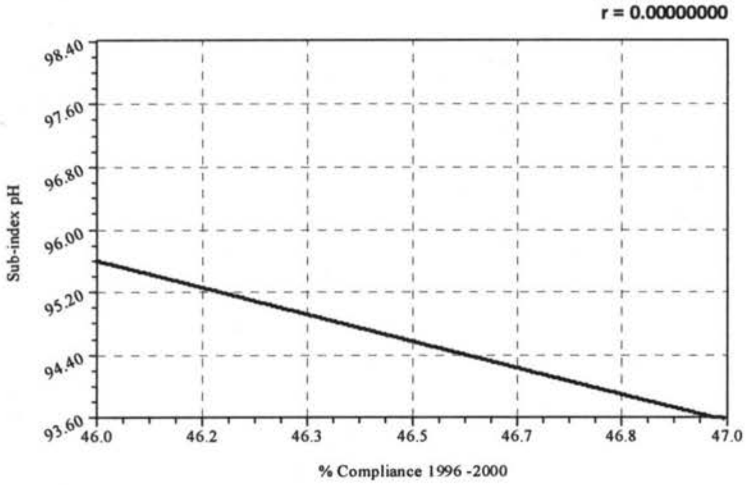
Power Fit: y=ax^b
Coefficient Data:

a =	21.94657
b =	0.014507



Power Fit: y=ax^b
Coefficient Data:

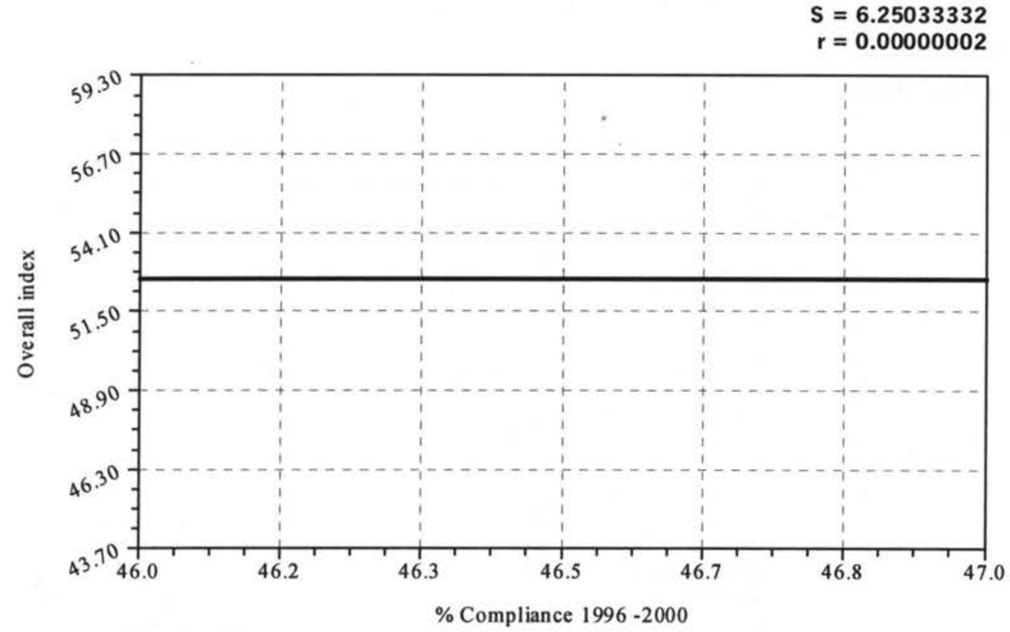
a =	490.211
b =	-0.49956



Power Fit: y=ax^b
Coefficient Data:

a =	4397.38
b =	-0.99999

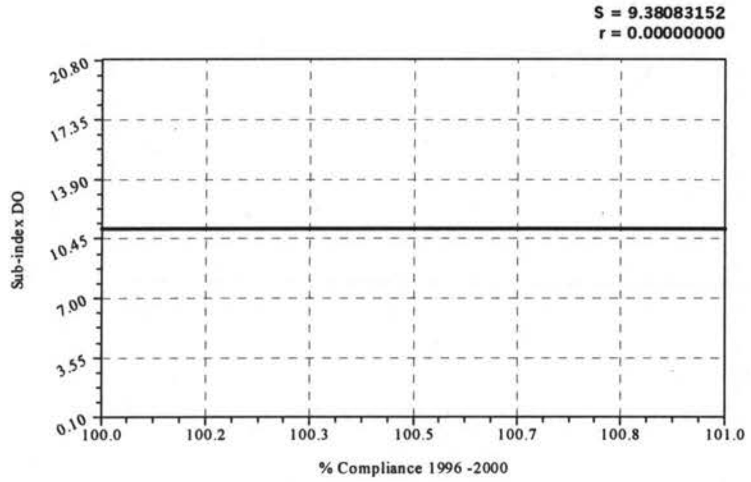
Figure 4.5 : Percent Compliance Bt. Berendam (Free Trade Zone) vs Sub-index Station 2322603, 1996-2000



Power Fit: y=ax^b
Coefficient Data:

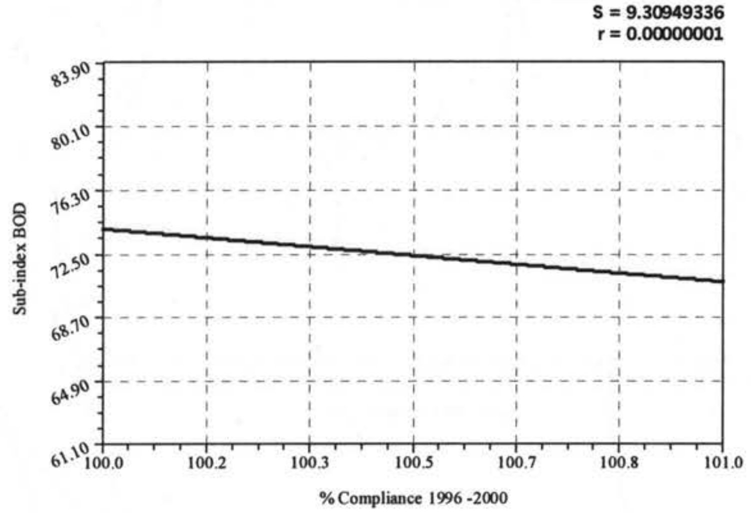
a = 52.4845
b = 0.000574

Figure 4.6 : Percent Compliance Bt. Berendam (Free Trade Zone) vs Overall index Station 2322603, 1996-2000



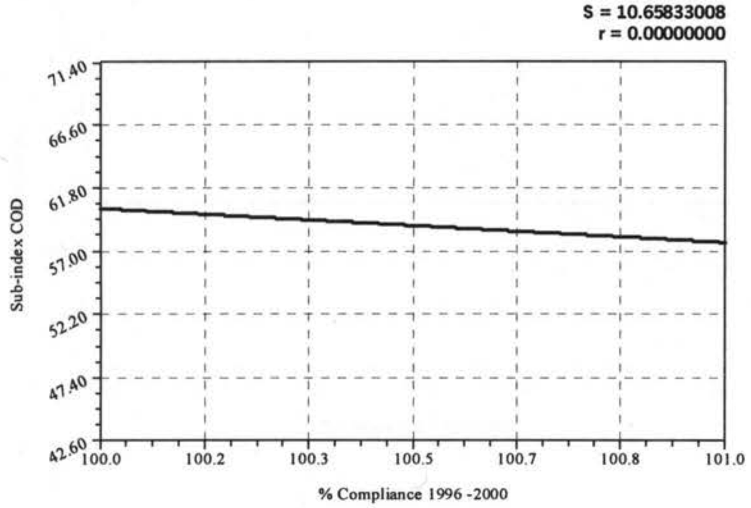
Geometric Fit: y=ax^(bx)
Coefficient Data:

a =	8.792267
b =	0.000486



Geometric Fit: y=ax^(bx)
Coefficient Data:

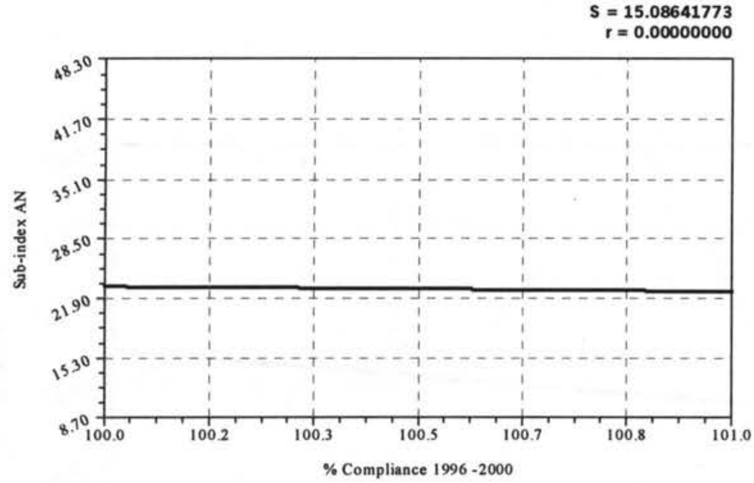
a =	2695.693
b =	-0.00781



Geometric Fit: y=ax^(bx)
Coefficient Data:

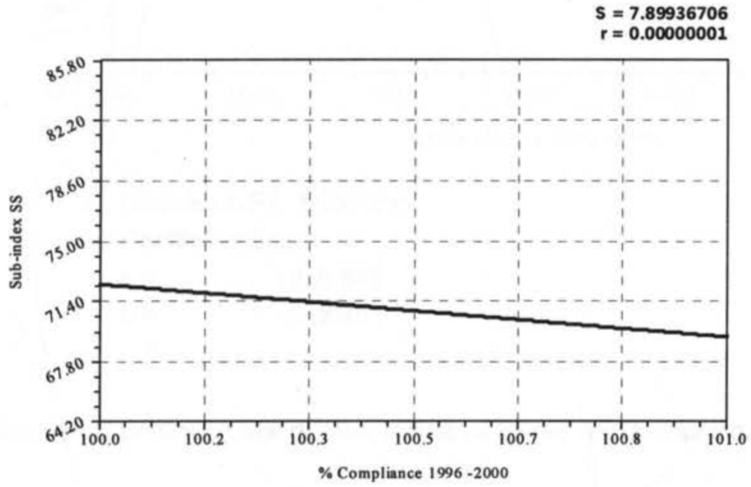
a =	2186.817
b =	-0.0078

Figure 4.7 : Percent Compliance Malim Jaya Industrial Estate vs Sub-index Station 2322603, 1996-2000



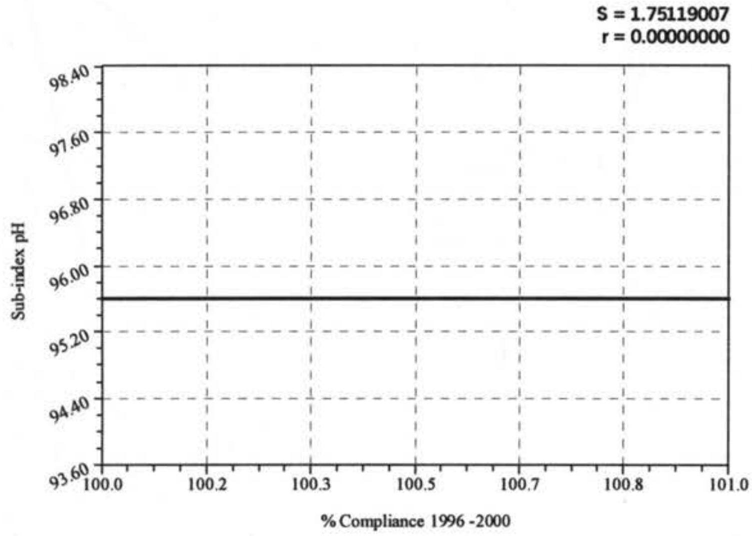
Modified Geometric Fit:
a*x^(b/x)
Coefficient Data:

a = 1.151772
b = 65.20607



Geometric Fit: y=ax^(bx)
Coefficient Data:

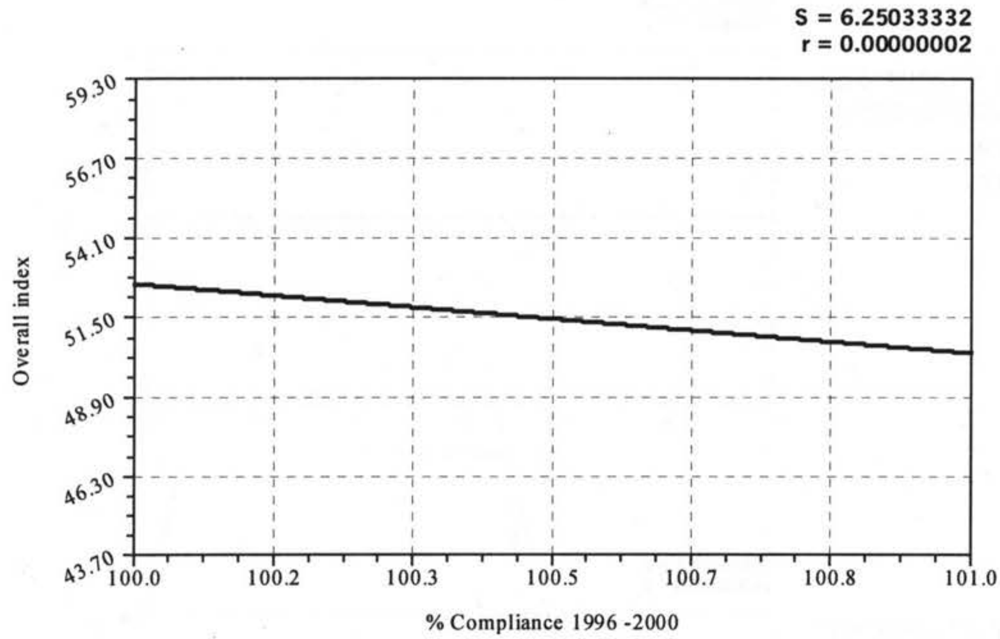
a = 2639.394
b = -0.00781



Modified Geometric Fit:
a*x^(b/x)
Coefficient Data:

a = 95.59522
b = 0.001085

Figure 4.8 : Percent Compliance Malim Jaya Industrial Estate vs Sub-index Station 2322603, 1996-2000



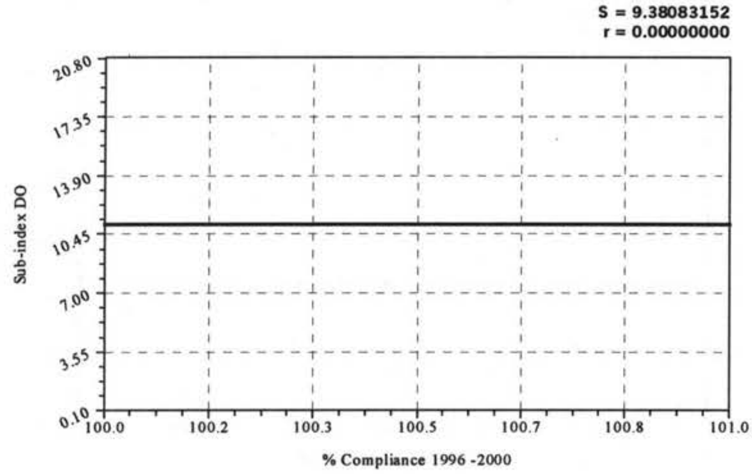
Geometric Fit: y=ax^(bx)

Coefficient Data:

a = 1916.599

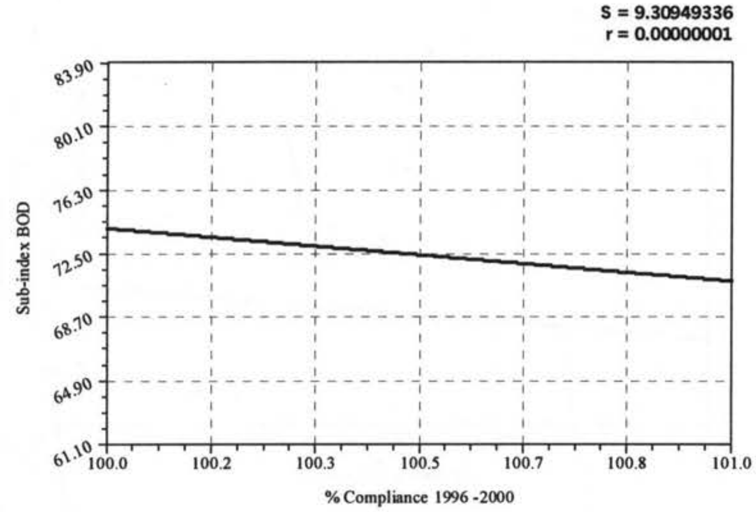
b = -0.00781

Figure 4.9 : Percent Compliance Malim Jaya Industrial Estate vs Overall index Station 2322603, 1996-2000



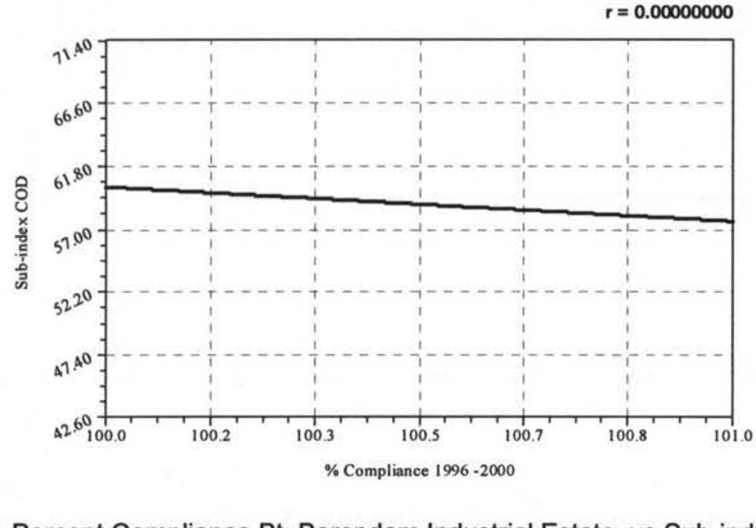
Geometric Fit: y=ax^(bx)
Coefficient Data:

a = 8.792267
b = 0.000486



Geometric Fit: y=ax^(bx)
Coefficient Data:

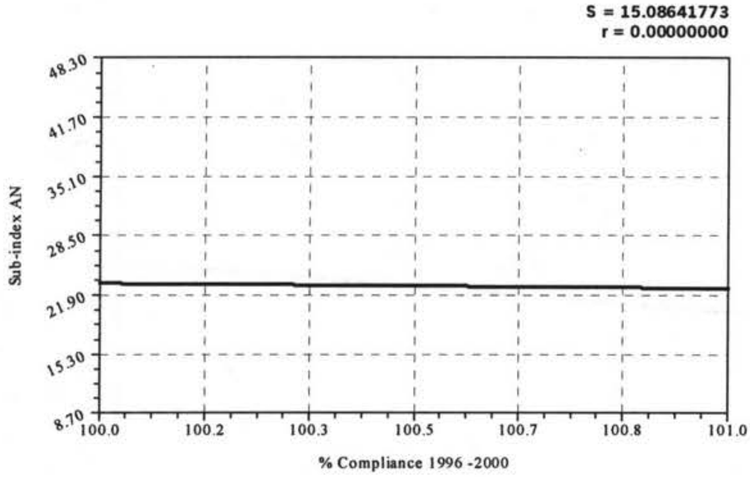
a = 2695.693
b = -0.00781



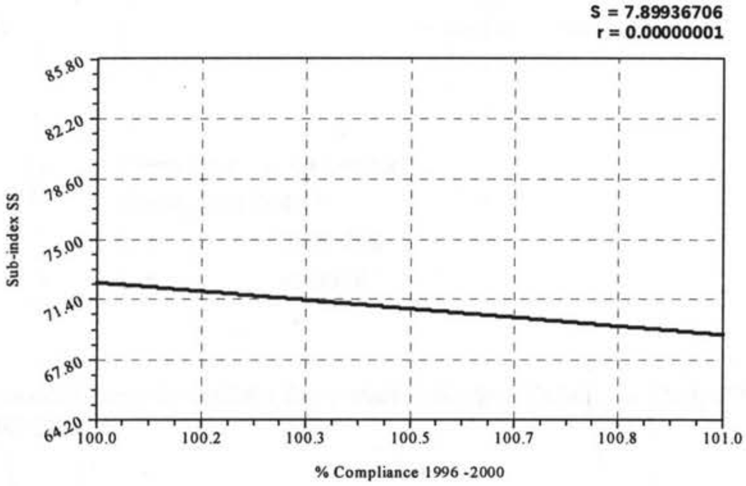
Geometric Fit: y=ax^(bx)
Coefficient Data:

a = 2186.817
b = -0.0078

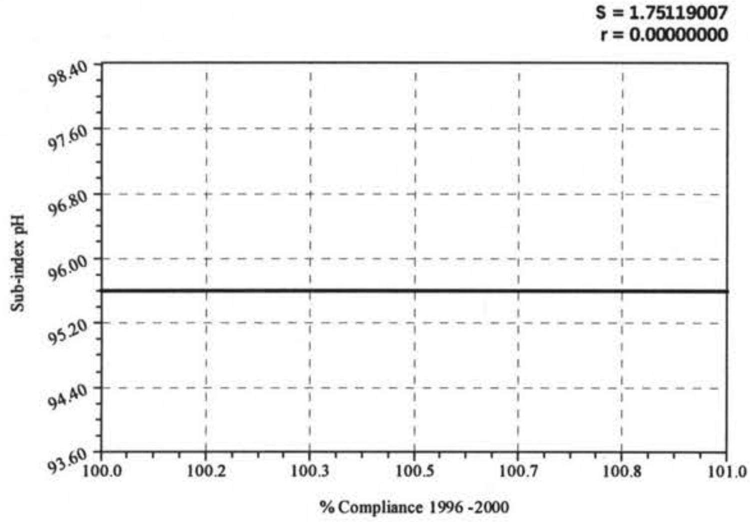
Figure 4.10 : Percent Compliance Bt. Berendam Industrial Estate vs Sub-index Station 2322603, 1996-2000



Modified Geometric Fit:
a*x^(b/x)
Coefficient Data:
a = 1.151772
b = 65.20607

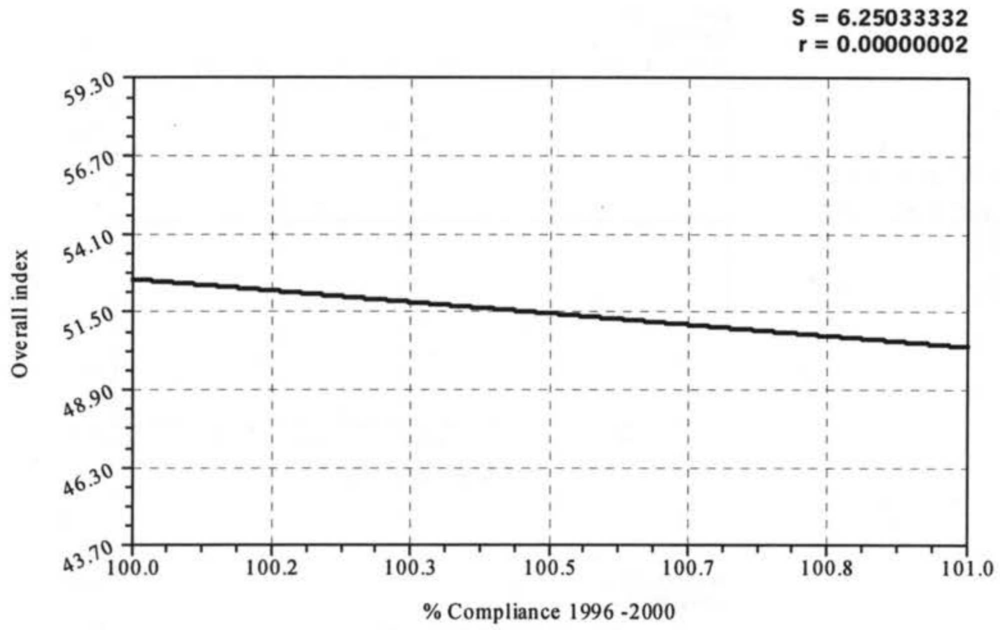


Geometric Fit: y=ax^(bx)
Coefficient Data:
a = 2639.394
b = -0.00781



Modified Geometric Fit:
a*x^(b/x)
Coefficient Data:
a = 95.59522
b = 0.001085

Figure 4.11: Percent Compliance Batu Berendam Industrial Estate vs Sub-index Station 2322603, 1996-2000



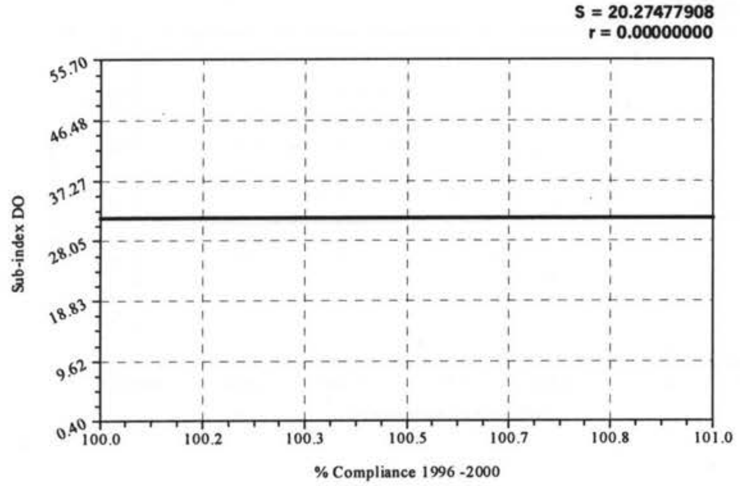
Geometric Fit: y=ax^(bx)

Coefficient Data:

a = 1916.599

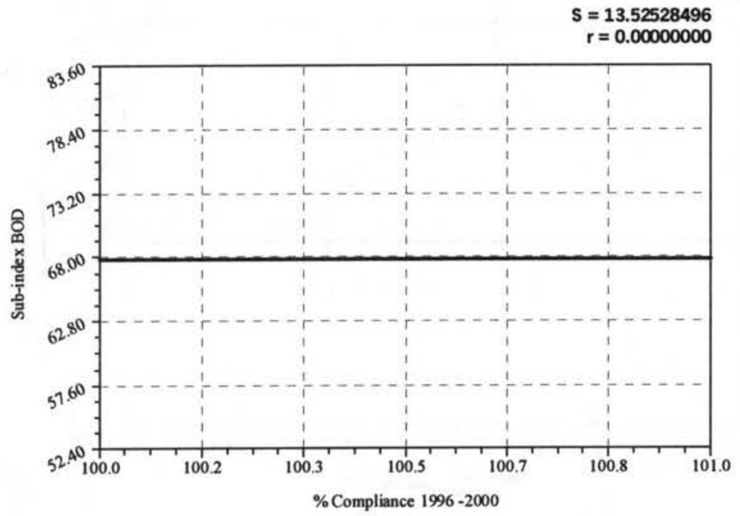
b = -0.00781

Figure 4.12 : Percent Compliance Batu Berendam Industrial Estate vs Overall index Station 2322603, 1996-2000



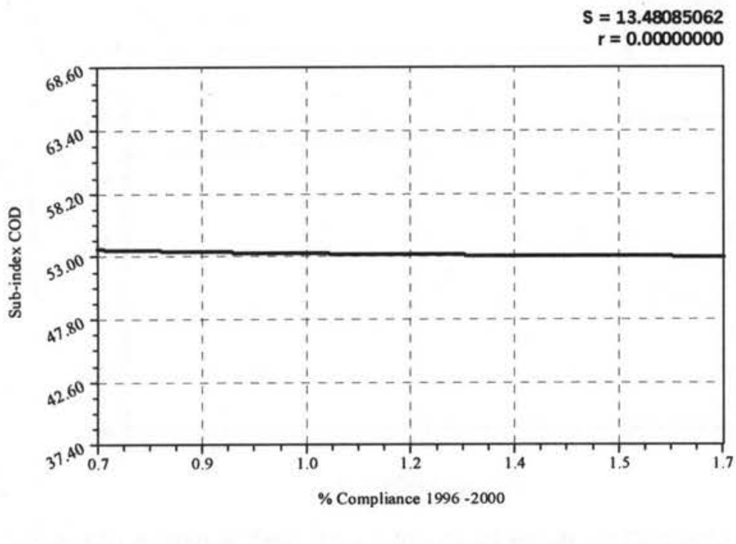
Geometric Fit: y=ax^(bx)
Coefficient Data:

a =	27.39534
b =	0.00031



Geometric Fit:
y=ax^(bx)
Coefficient Data:

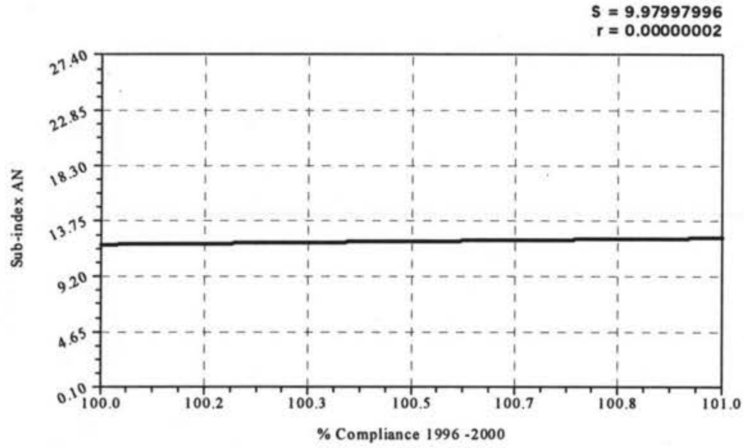
a =	67.3962
b =	1.30E-05



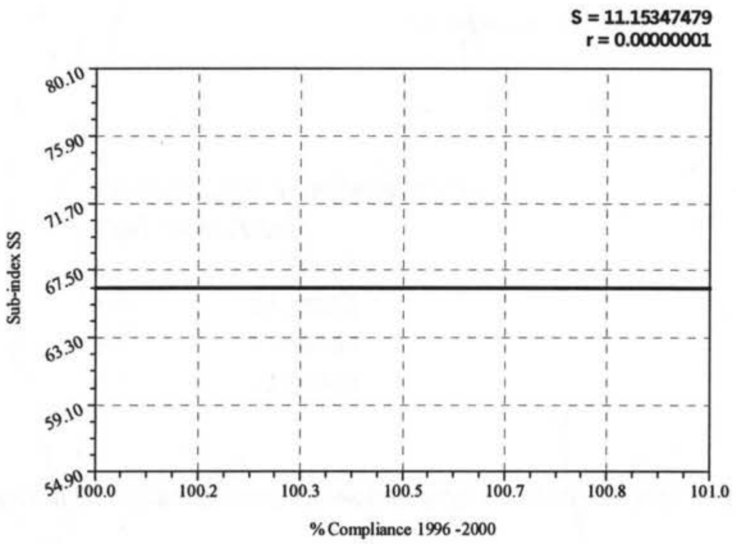
Saturation Growth
Model:
y=ax/(b+x)
Coefficient Data:

a =	52.55575
b =	-1.35E-02

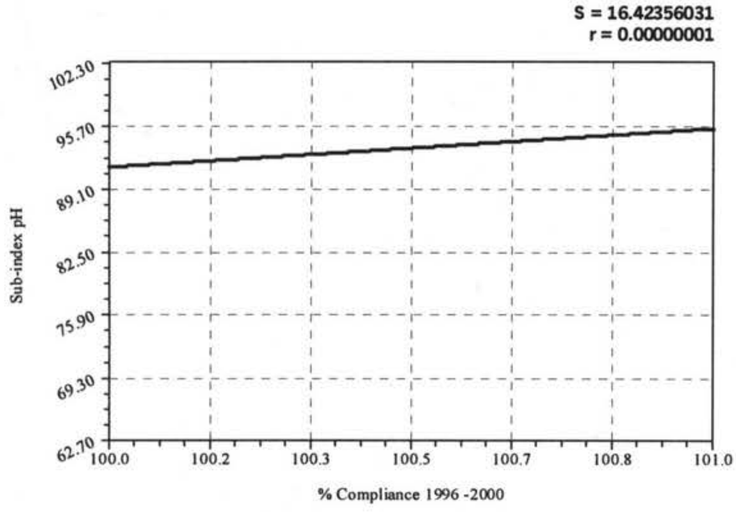
Figure 4.13 : Percent Compliance Tmn. Tasek Industrial Estate vs Sub-Index Station 2322604, 1996-2000



User-Defined Model:
y=a+b*x
Coefficient Data:
a = -43.6
b = 0.554

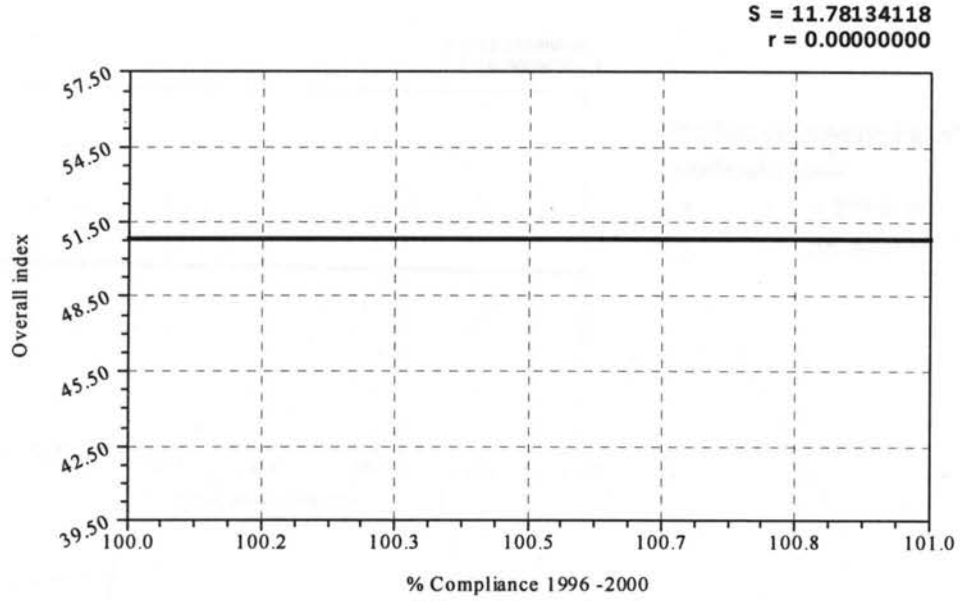


User-Defined Model:
y=a+b*x
Coefficient Data:
a = -43.6
b = 0.554



Geometric Fit: y=ax^(bx)
Coefficient Data:
a = 2.488656
b = 0.007825

Figure 4.14 : Percent Compliance Tmn. Tasek Industrial Estate vs Sub-Index Station 2322604, 1996-2000

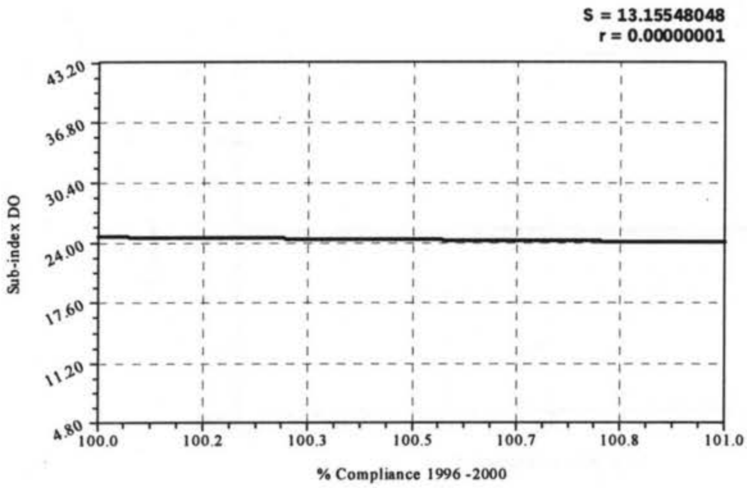


Weibull Model: y=a-b*exp(-c*x^d)

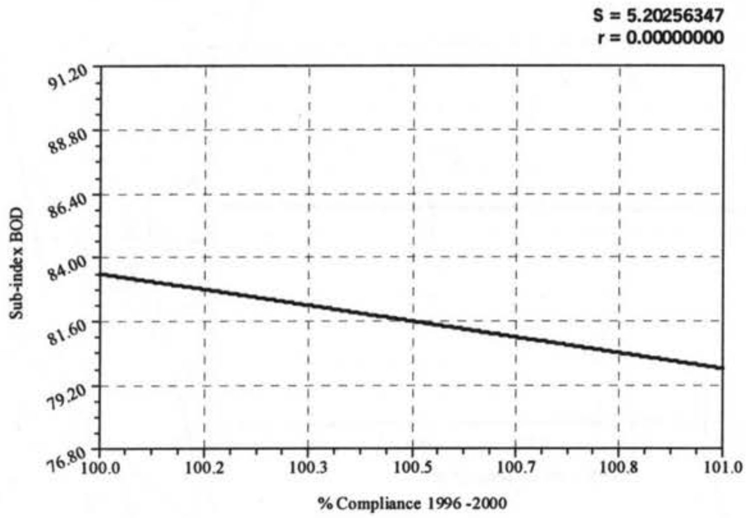
Coefficient Data:

a =	61.57
b =	37.10395
c =	1.239759
d =	-0.00049

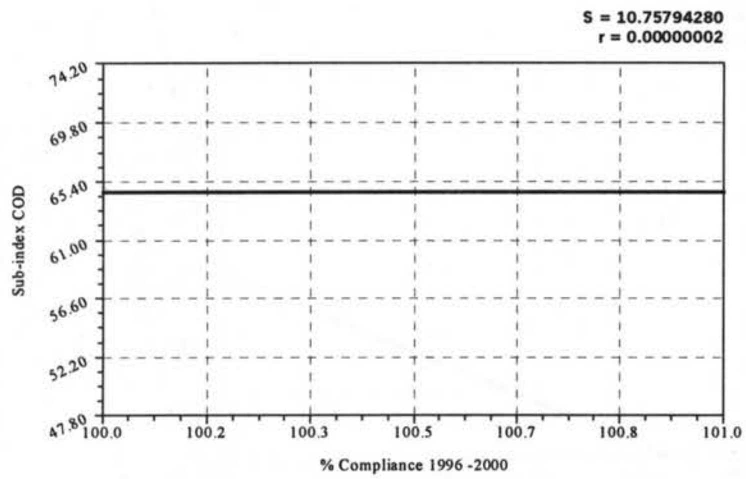
Figure 4.15 : Percent Compliance Tmn. Tasek Industrial Estate vs Overall Index Station 2322604, 1996-2000



Modified Geometric Fit: a*x^(b/x)
Coefficient Data:
a = 1.215478
b = 65.30941

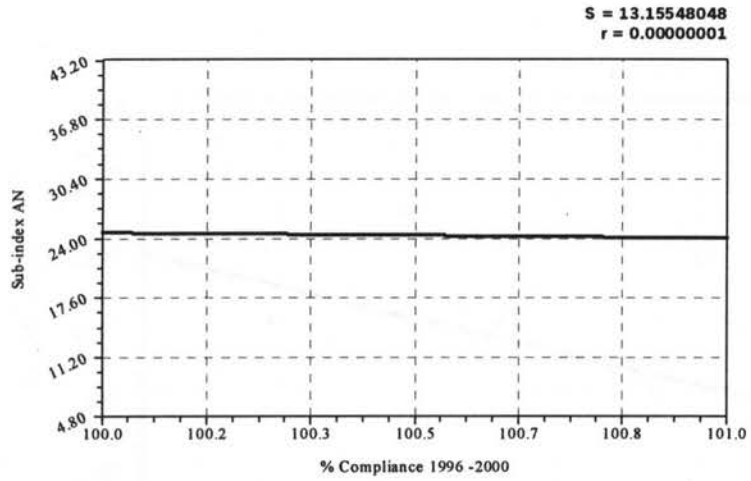


Geometric Fit: y=ax^(bx)
Coefficient Data:
a = 3043.792
b = -0.00781



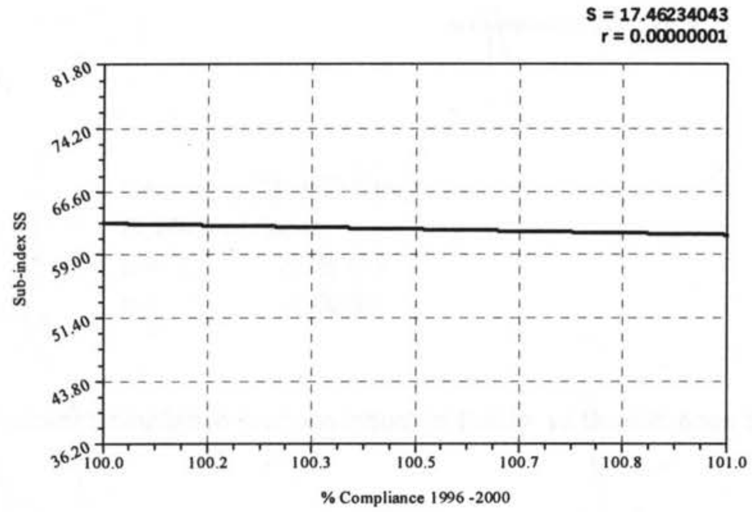
Geometric Fit: y=ax^(bx)
Coefficient Data:
a = 64.30752
b = 9.85E-06

Figure 4.16 : Percent Compliance Krubong Industrial Estate vs Sub-index Station 2322605, 1996-2000



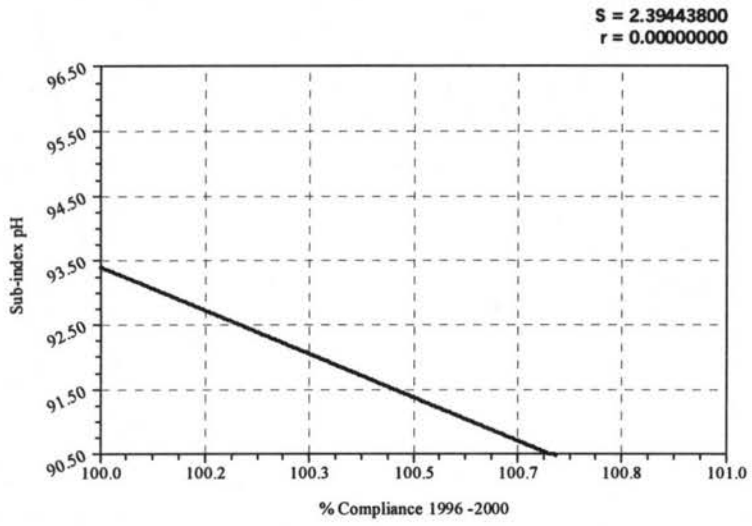
Modified Geometric Fit:
a*x^(b/x)
Coefficient Data:

a =	1.215478
b =	65.30941



Modified Geometric Fit:
a*x^(b/x)
Coefficient Data:

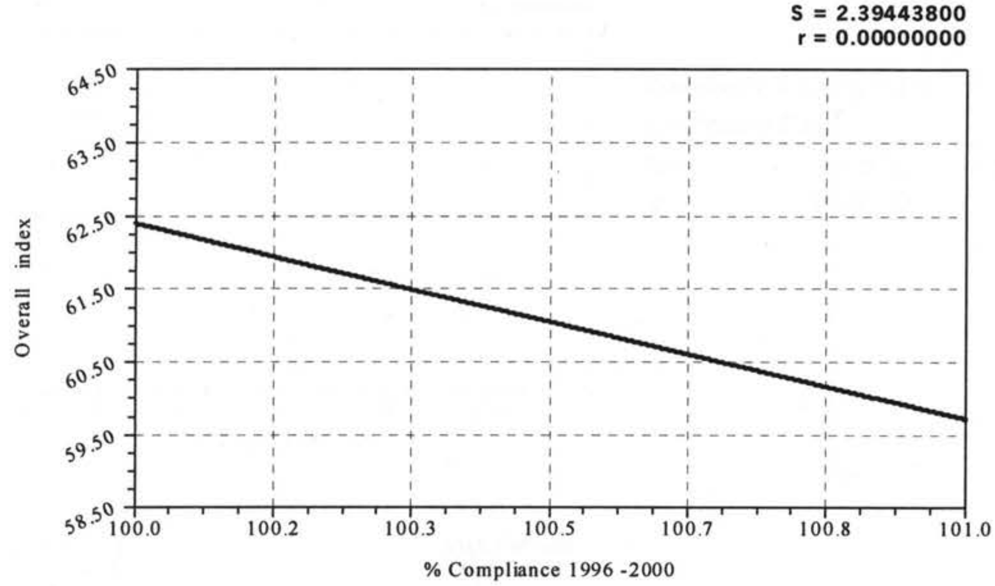
a =	3.252204
b =	64.28909



Geometric Fit: y=ax^(bx)
Coefficient Data:

a =	3410.391
b =	-0.00781

Figure 4.17 : Percent Compliance Krubong Industrial Estate vs Sub-index Station 2322605, 1996-2000

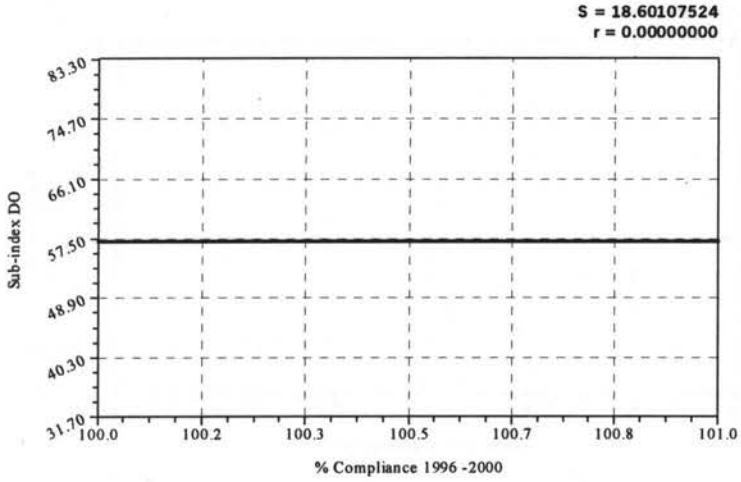


Geometric Fit: y=ax^(bx)

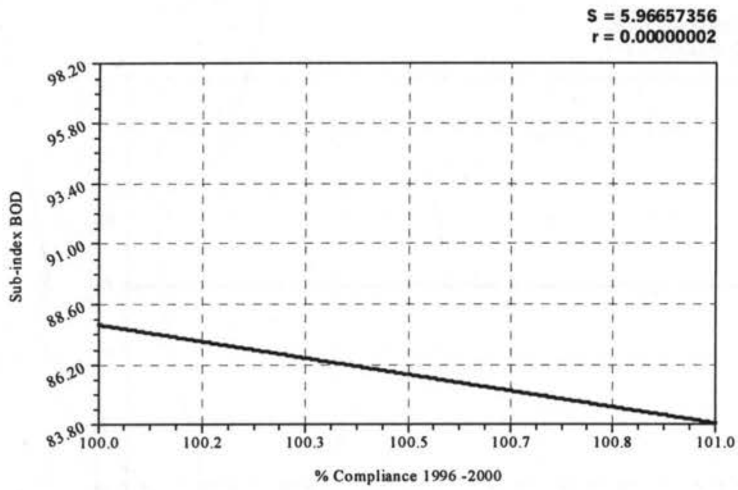
Coefficient Data:

a =	2278.173
b =	-0.00781

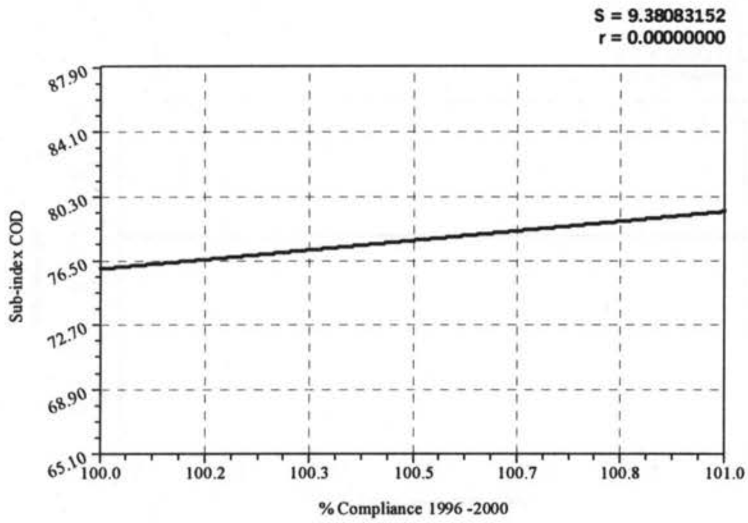
Figure 4.18 : Percent Compliance Krubong Industrial Estate vs Overall index Station 2322605, 1996-2000



Geometric Fit: y=ax^(bx)
Coefficient Data:
a = 56.0435
b = 3.67E-05

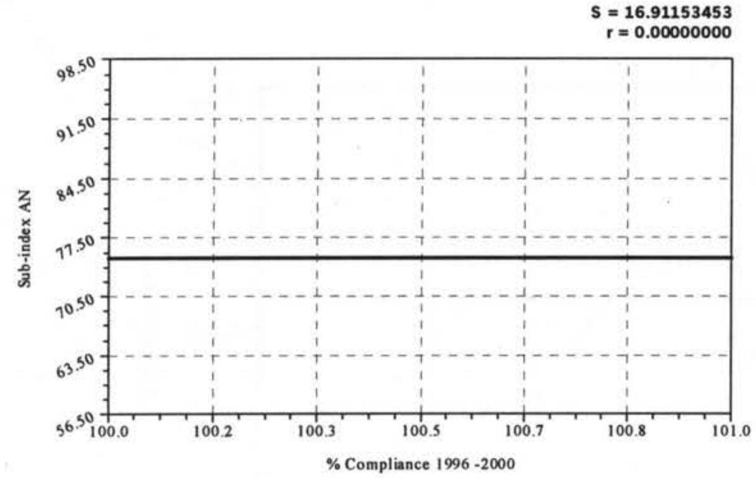


Modified Geometric Fit:
a*x^(b/x)
Coefficient Data:
a = 0.241662
b = 128.0143



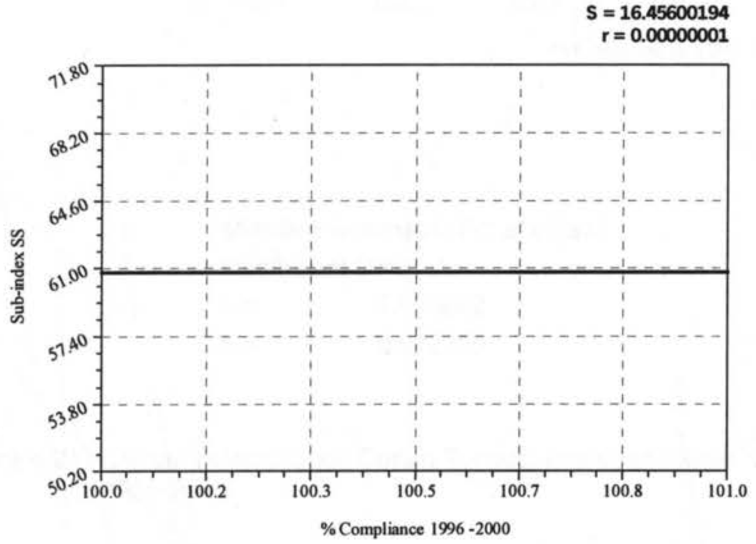
Geometric Fit: y=ax^(bx)
Coefficient Data:
a = 2.076489
b = 0.007817

Figure 4.19 : Percent Compliance Durian Tunggal Industrial Estate vs Sub-index Station 2322607, 1996-2000



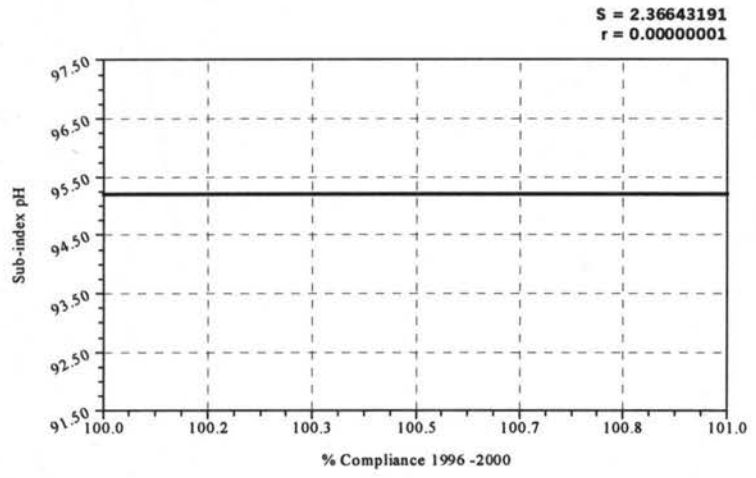
Modified Geometric Fit: a*x^(b/x)
Coefficient Data:

a =	74.4329
b =	0.164816



Weibull Model: y=a-b*exp(-c*x^d)
Coefficient Data:

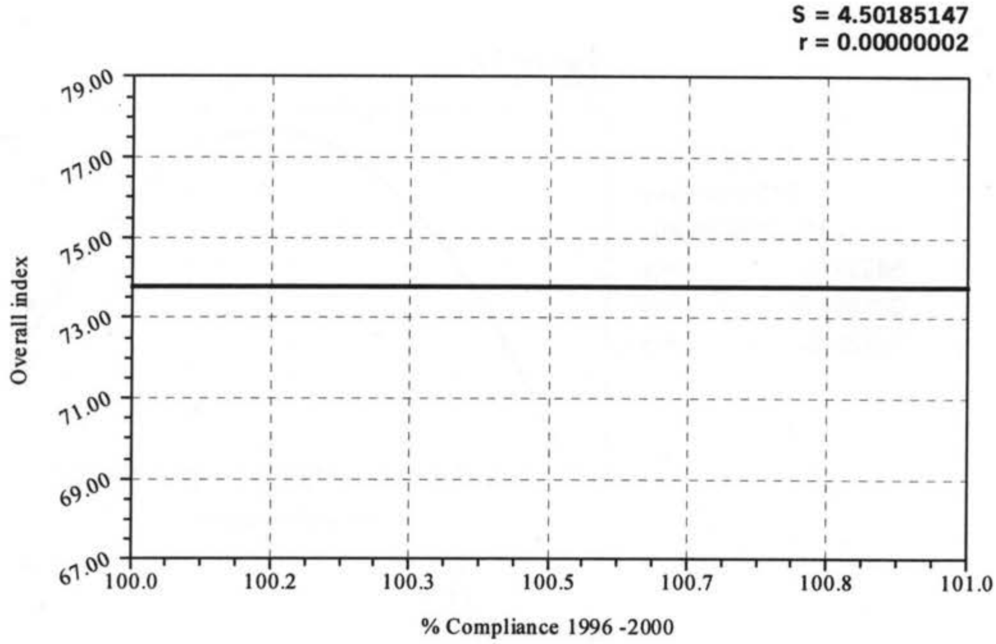
a =	76.95437
b =	45.93049
c =	1.209953
d =	-0.03184



Modified Geometric Fit: a*x^(b/x)
Coefficient Data:

a =	95.1911
b =	0.002031

Figure 4.20 : Percent Compliance Durian Tunggal Industrial Estate vs Sub-index Station 2322607, 1996-2000

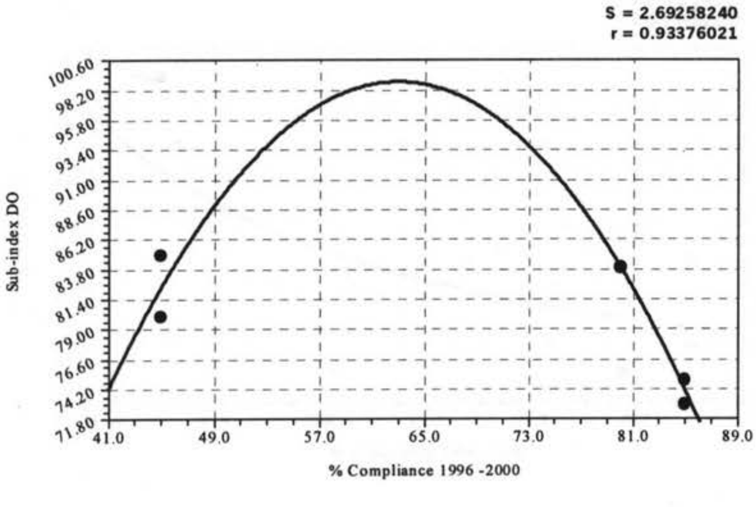


Modified Geometric Fit: a*x^(b/x)

Coefficient Data:

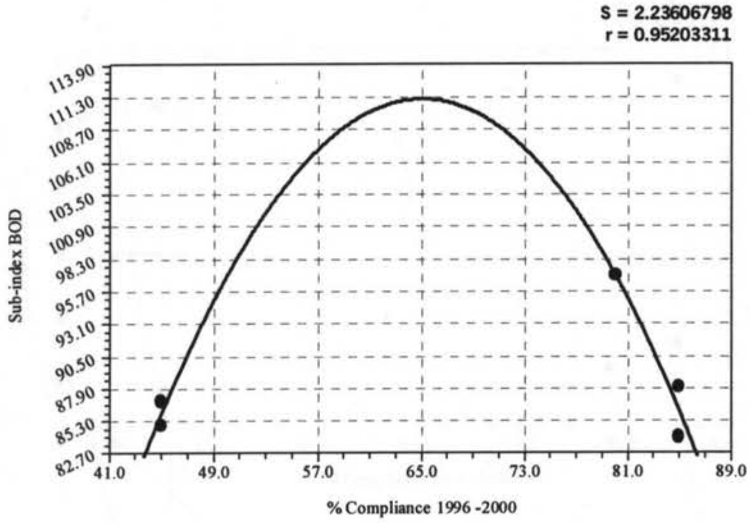
a =	73.75802
b =	0.012356

Figure 4.21 : Percent Compliance Durian Tunggal Industrial Estate vs Overall Index Station 2322607, 1996-2000



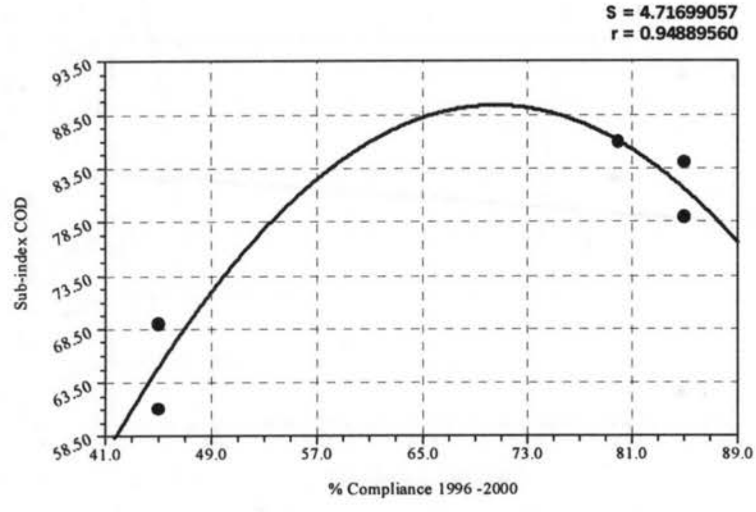
Quadratic Fit:
y=a+bx+cx^2
Coefficient Data:

a =	-103.286
b =	6.426786
c =	-0.05107



Quadratic Fit: y=a+bx+cx^2
Coefficient Data:

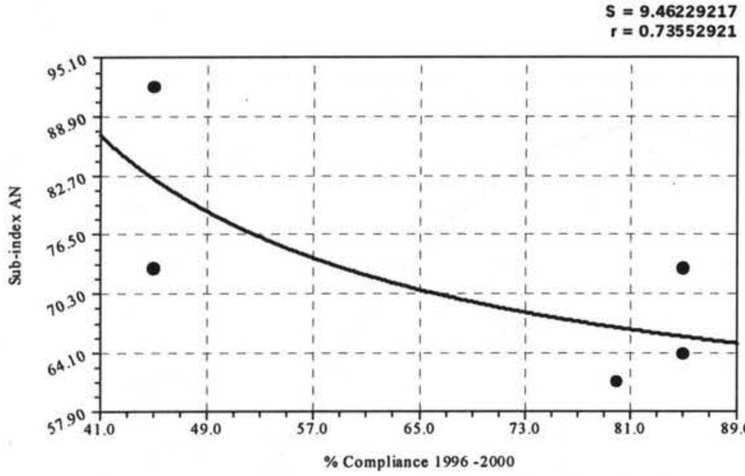
a =	-154.429
b =	8.171429
c =	-0.06286



Quadratic Fit: y=a+bx+cx^2
Coefficient Data:

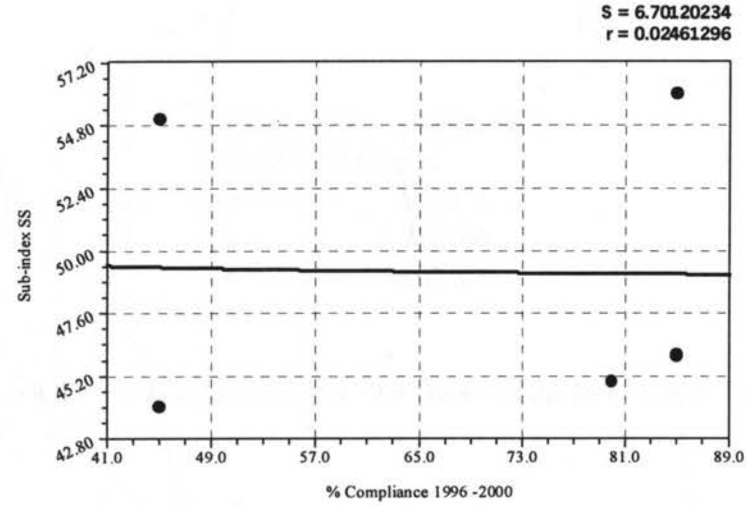
a =	-97
b =	5.2875
c =	-0.0375

Figure 4.22 : Percent Compliance Alor Gajah Industrial Estate vs Sub-index Station 2322610, 1996-2000



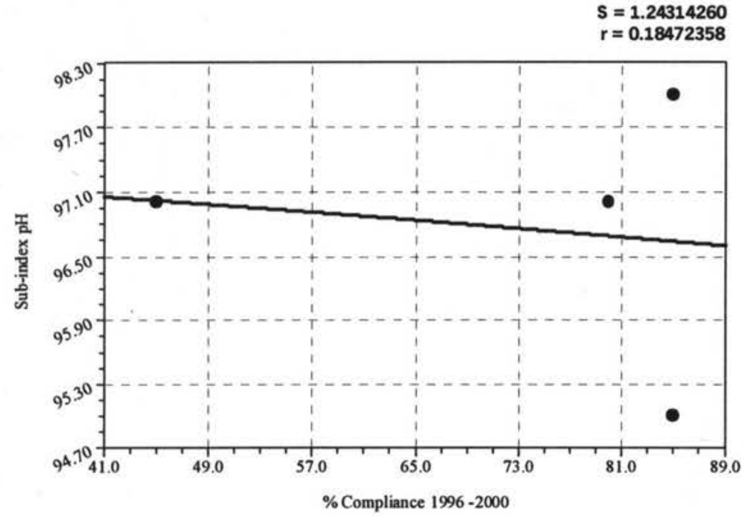
Saturation Growth-Rate Model:
y=ax/(b+x)
Coefficient Data:

a =	53.61179
b =	-15.7104



Saturation Growth-Rate Model:
y=ax/(b+x)
Coefficient Data:

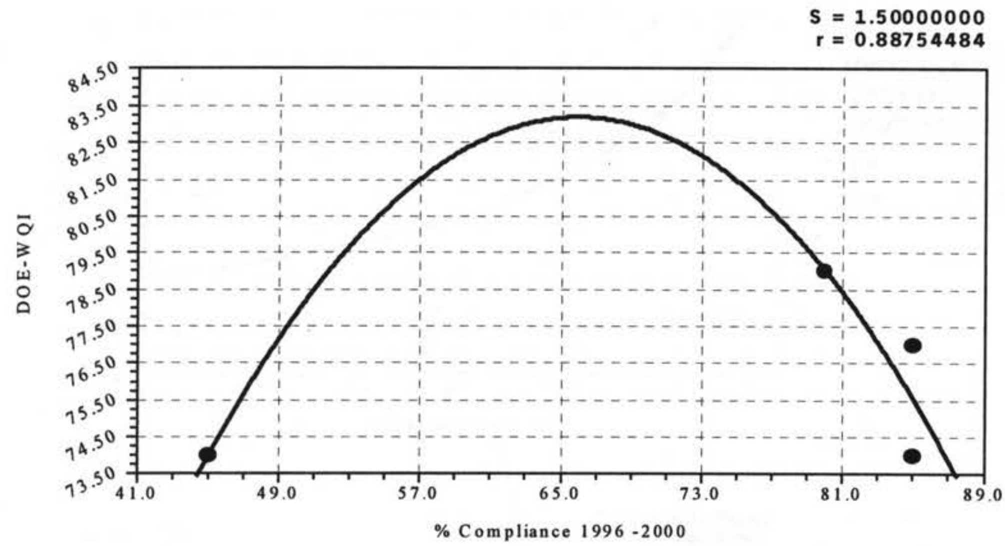
a =	48.79103
b =	-0.51605



Geometric Fit: y=ax^(bx)
Coefficient Data:

a =	97.34068
b =	-1.92E-05

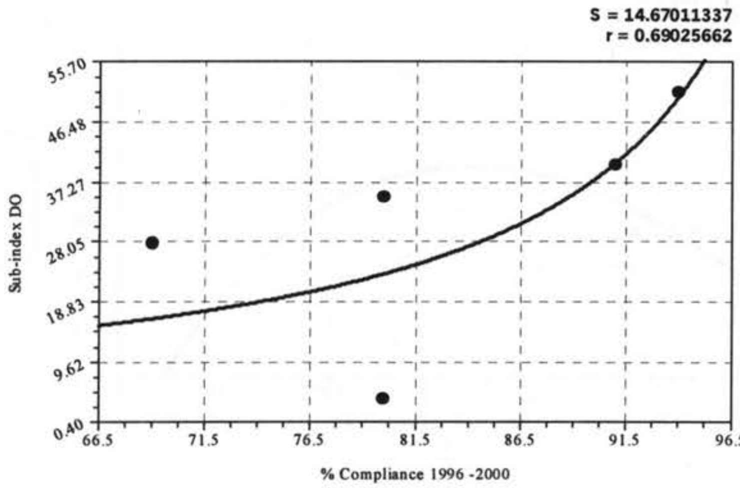
Figure 4.23 : Percent Compliance Alor Gajah Industrial Estate vs Sub-index Station 2322610, 1996-2000



Quadratic Fit: y=a+bx+cx^2
Coefficient Data:

a =	-8.28571
b =	2.776786
c =	-0.02107

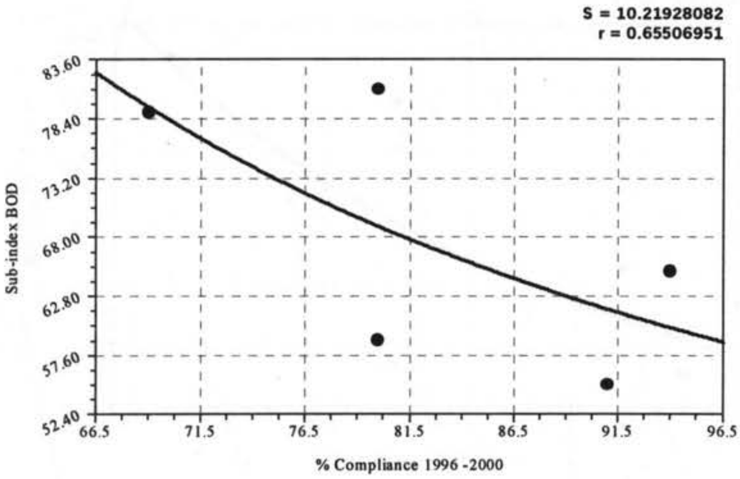
Figure 4.24 : Percent Compliance Alor Gajah Industrial Estate vs Overall Index Station 2322610, 1996-2000



Reciprocal Model:
y=1/(ax+b)
Coefficient Data:

a = -0.00167

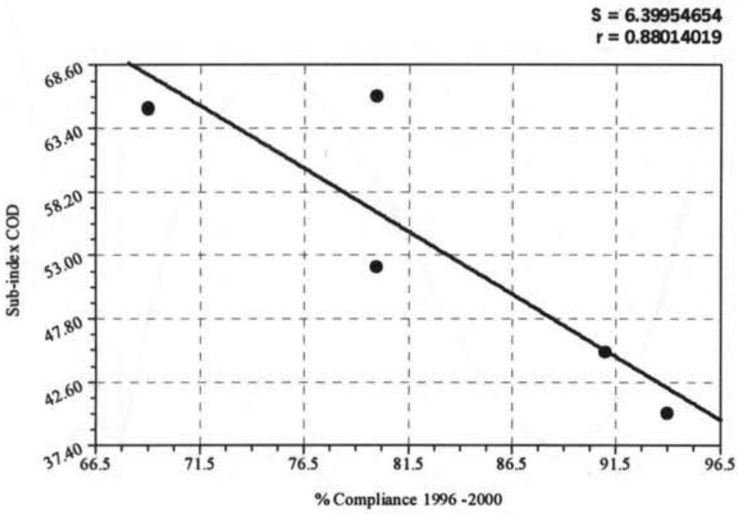
b = 0.176544



Modified Geometric Fit:
a*x^(b/x)
Coefficient Data:

a = 2.13E+01

b = 21.46308

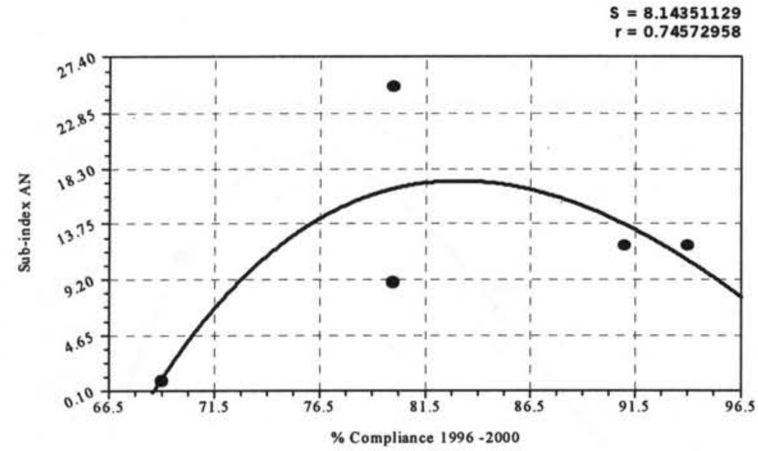


User-Defined Model:
y=a+b*x
Coefficient Data:

a = 138.8084

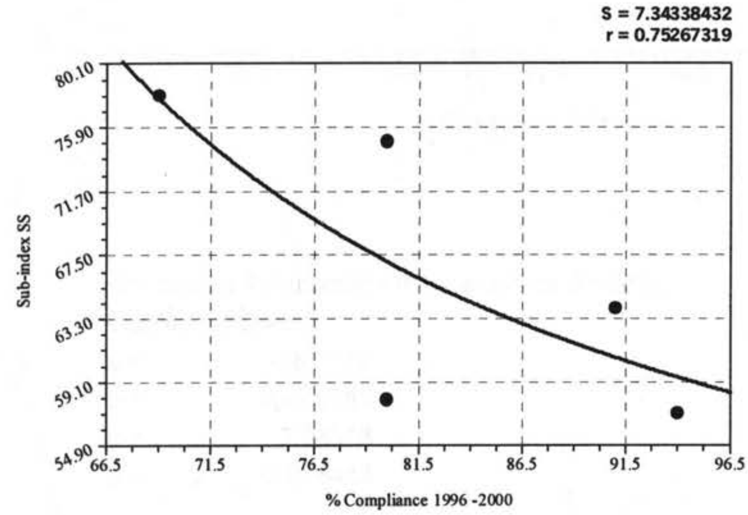
b = -1.02909

Figure 4.25 : Percent Compliance Ayer Keroh Industrial Estate vs. Sub-index station 2322604, 1996-2000



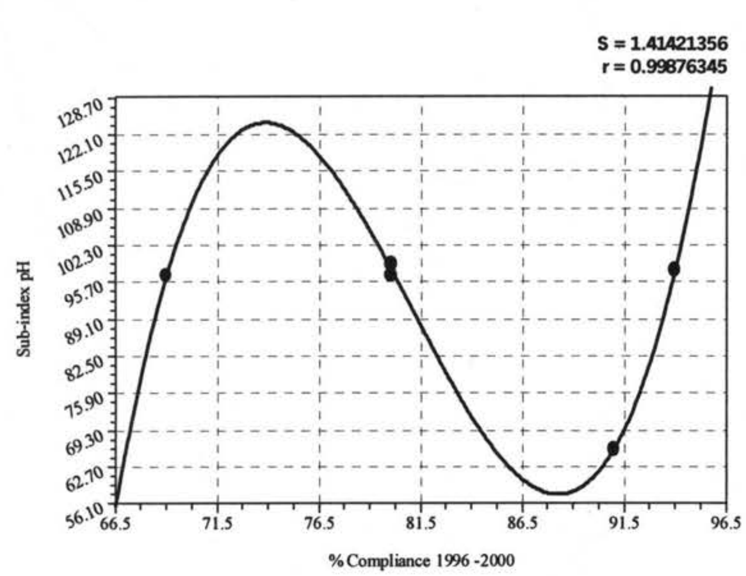
Heat Capacity Model:
y=a+bx=c/x^2
Coefficient Data:

a =	458.1602
b =	-3.53985
c =	-1012997



Saturation Growth-Rate Model
y=ax/(b+x)
Coefficient Data:

a =	35.9473
b =	-37.1125

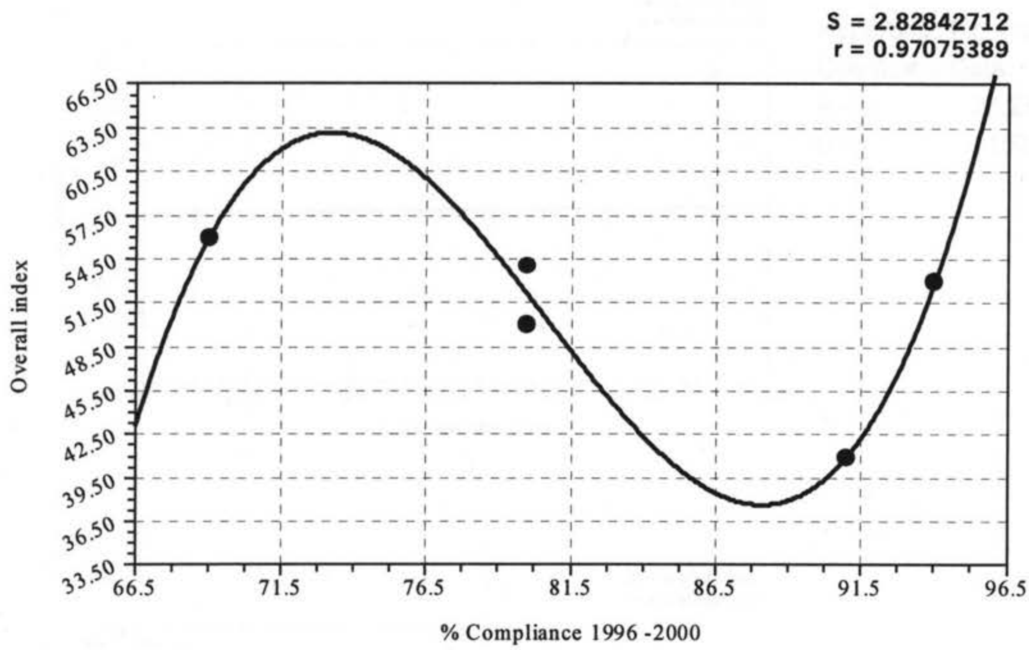


3rd degree polynomial Fit:
y=a+bx+cx^2+dx^3...

Coefficient Data:

a =	-22885.9
b =	864.5103
c =	-10.7545
d =	0.044242

Figure 4.26 : Percent Compliance Ayer Keroh Industrial Estate vs. Sub-index station 2322604, 1996-2000

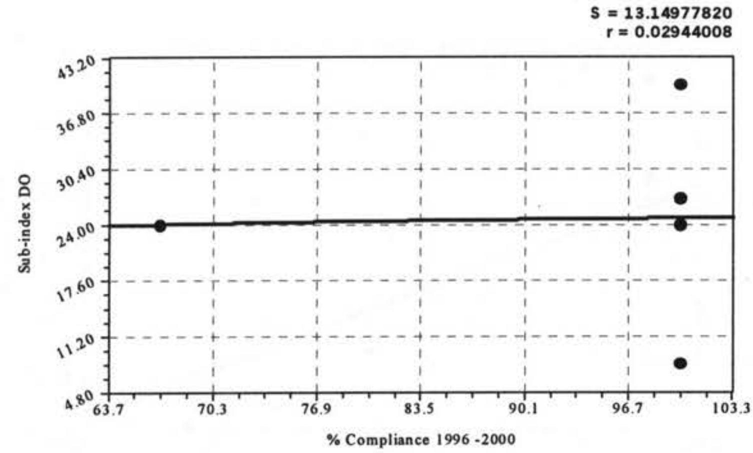


3rd degree Polynomial Fit: y=a+bx+cx^2+dx^3...

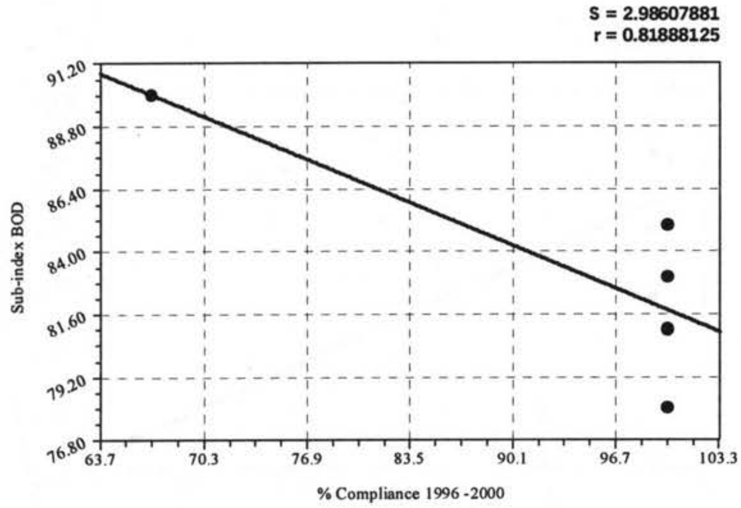
Coefficient Data:

a =	-7835.78
b =	298.5783
c =	-3.73518
d =	0.015443

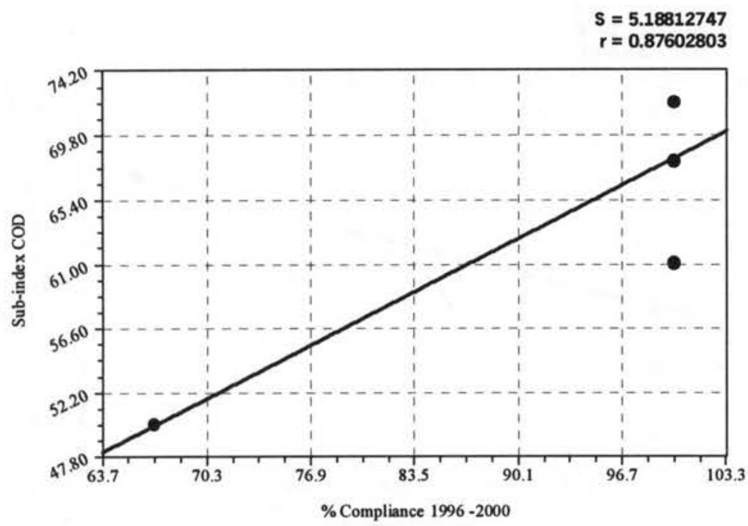
Figure 4.27 : Percent Compliance Ayer Keroh Industrial Estate vs. Overall index station 2322604, 1996-200



Hyperbolic Fit: y=a+b/x
Coefficient Data:
a = 26.27273
b = -152.273

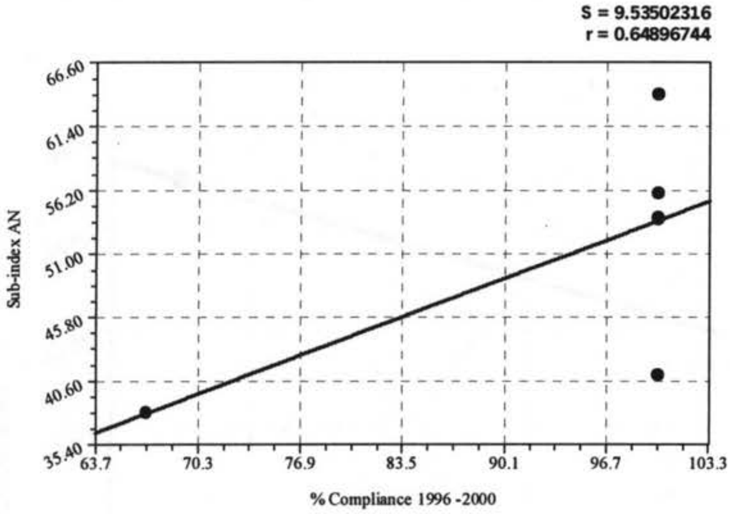


Linear Fit: y=a+bx
Coefficient Data:
a = 106.75
b = -0.25

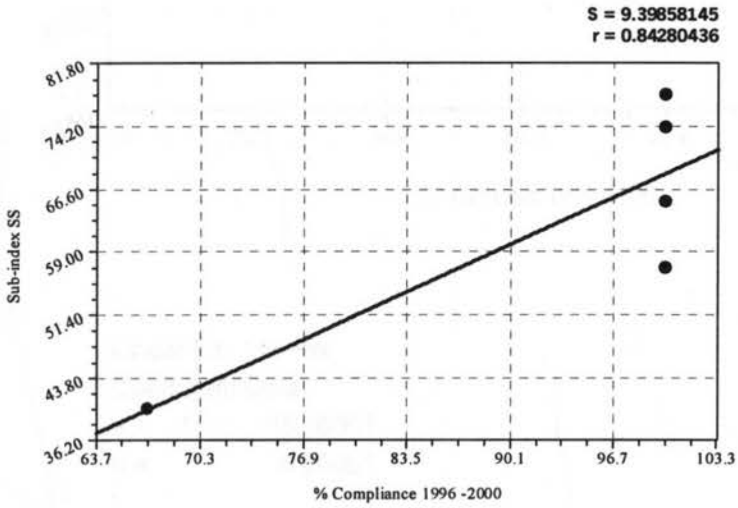


Linear Fit: y=a+bx
Coefficient Data:
a = 12.94697
b = 0.55303

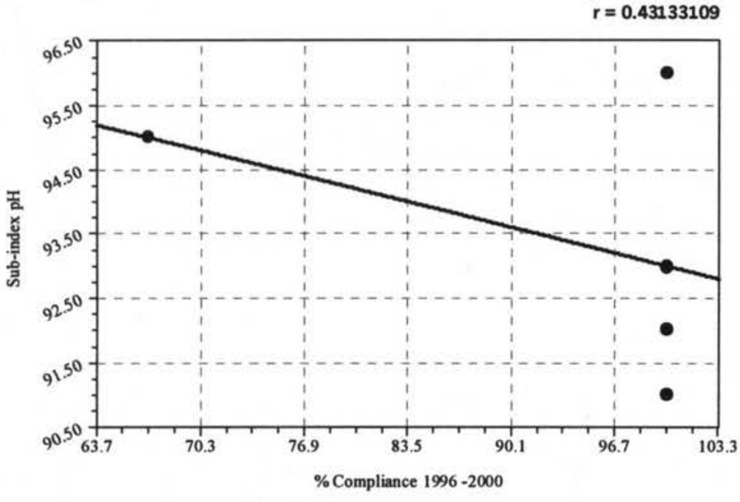
Figure 4.28 : Percent Compliance Cheng Industrial Estate vs. Sub-index Station 2322605, 1996-2000



Linear Fit: y=a+bx
Coefficient Data:
a = 6.022727
b = 0.477273

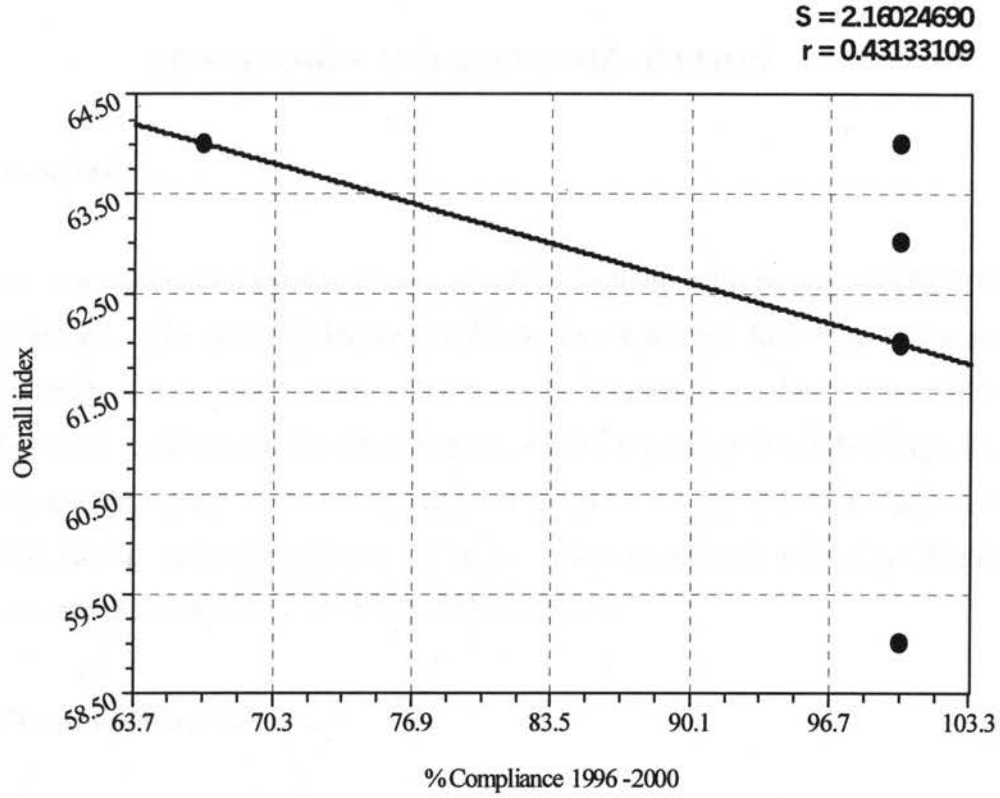


Linear Fit: y=a+bx
Coefficient Data:
a = -17.8636
b = 0.863636



Linear Fit: y=a+bx
Coefficient Data:
a = 99.06061
b = -0.06061

Figure 4.29 : Percent Compliance Cheng Industrial Estate vs. Sub-index Station 2322605, 1996-2000



Linear Fit: y=a+bx
Coefficient Data:
a = 68.06061
b = -0.06061

Figure 4.30 : Percent Compliance Cheng Industrial Estate vs. Overall index Station 2322605, 1996-2000

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Three out of ten industrial estates show a substantial relationship between DOE-WQI and compliance. The non relationship could be due to several factors as discussed earlier. The three industrial estates which have the relationship indicated that DOE-WQI can be use to determine the effectiveness of EQA especially if the discharges are highly organic in nature as shown in Figure 4.22 and 4.30, for the Alor Gajah, Air Keroh and Cheng Industrial Estates. The sub-index parameters which are highly correlated with the compliance are BOD, COD and AN.

5.2 Recommendations

In order to achieve a higher correlation between industrial compliance and water quality status using the DOE-WQI it is recommended that:-

1. Location of the sampling station must be more representative for a particular industrial estate.

2. The time of sampling must be in accordance with the industries operation hour.

3. The parameter for specific type of industries should be reviewed.

4. Reviewing of sampling station should be carried out whenever there is major changes of landuse pattern.

5. Minimising the contribution from the non-point source is necessary to achieve greater relationship.

6. A triggering mechanism should be developed in the self-monitoring report.

7. For non-compliance event there should be check and balance mechanism or other means such as production activity etc. to gauge the actual compliance.

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APPENDIX A

DATA FOR COMPUTATION OF WQI

SNO	SUNGAI	WQI 96
2222601	MELAKA	52
2222601	MELAKA	50
2222601	MELAKA	46
2222603	MELAKA	53
2222603	MELAKA	52
2222603	MELAKA	59
2222604	PUTAT	39
2222604	PUTAT	43
2222604	PUTAT	-
2222605	MELAKA	62
2222605	MELAKA	NA
2222605	MELAKA	67
2222607	MELAKA	79
2222607	MELAKA	79
2222607	MELAKA	67
2322608	DURIAN TUNGGAL	87
2322608	DURIAN TUNGGAL	88
2322608	DURIAN TUNGGAL	89
2322610	MELAKA	82
2322610	MELAKA	76
2322610	MELAKA	77
2322613	MELAKA	88
2322613	MELAKA	80
2322613	MELAKA	76
2423614	BTG. MELAKA	84
2423614	BTG. MELAKA	78
2423614	BTG. MELAKA	70
2423616	BTG. MELAKA	82
2423616	BTG. MELAKA	84
2423616	BTG. MELAKA	-
2522615	TAMPIN	91
2522615	TAMPIN	86
2522615	TAMPIN	82

SNO	SUNGAI	WQI 97
2222601	MELAKA	48
2222601	MELAKA	49
2222601	MELAKA	55
2222601	MELAKA	33
2222603	MELAKA	37
2222603	MELAKA	56
2222603	MELAKA	54
2222603	MELAKA	49
2222605	MELAKA	64
2222605	MELAKA	63
2222605	MELAKA	57
2222605	MELAKA	54
2222607	MELAKA	65
2222607	MELAKA	65
2222607	MELAKA	73
2322607	MELAKA	69
2322610	MELAKA	69
2322610	MELAKA	66
2322610	MELAKA	81
2322610	MELAKA	80
2322613	MELAKA	75
2322613	MELAKA	76
2322613	MELAKA	79
2322613	MELAKA	76
2423616	BTG. MELAKA	71
2423616	BTG. MELAKA	83
2423616	BTG. MELAKA	83
2423616	BTG. MELAKA	82
2423614	BTG. MELAKA	63
2423614	BTG. MELAKA	56
2522614	BTG. MELAKA	76
2522614	BTG. MELAKA	83
2222604	PUTAT	46
2222604	PUTAT	48
2222604	PUTAT	51
2322608	PUTAT	56
2322608	DURIAN TUNGGAL	82
2322608	DURIAN TUNGGAL	80
2322608	DURIAN TUNGGAL	89
2522615	DURIAN TUNGGAL	87
2522615	TAMPIN	86
2522615	TAMPIN	83
2522615	TAMPIN	90
2522615	TAMPIN	86

SNO	SUNGAI	WQI 98
2222601	MELAKA	59
2222601	MELAKA	52
2222601	MELAKA	57
2222601	MELAKA	80
2222603	MELAKA	57
2222603	MELAKA	49
2222603	MELAKA	57
2222603	MELAKA	70
2222605	MELAKA	72
2222605	MELAKA	66
2222605	MELAKA	61
2222605	MELAKA	57
2222607	MELAKA	80
2222607	MELAKA	77
2222607	MELAKA	80
2322607	MELAKA	76
2322610	MELAKA	83
2322610	MELAKA	68
2322610	MELAKA	78
2322610	MELAKA	80
2322613	MELAKA	86
2322613	MELAKA	69
2322613	MELAKA	85
2322613	MELAKA	83
2423616	BTG. MELAKA	85
2423616	BTG. MELAKA	88
2423616	BTG. MELAKA	73
2423616	BTG. MELAKA	82
2423614	BTG. MELAKA	77
2423614	BTG. MELAKA	84
2522614	BTG. MELAKA	76
2522614	BTG. MELAKA	86
2222604	PUTAT	65
2222604	PUTAT	57
2222604	PUTAT	38
2322608	PUTAT	61
2322608	DURIAN TUNGGAL	[illegible]
2322608	DURIAN TUNGGAL	[illegible]
2322608	DURIAN TUNGGAL	80
2522615	DURIAN TUNGGAL	91
2522615	TAMPIN	88
2522615	TAMPIN	82
2522615	TAMPIN	88
2522615	TAMPIN	85

SNO	SUNGAI	WQI 99
2222601	MELAKA	73
2222601	MELAKA	55
2222601	MELAKA	56
2222601	MELAKA	44
2222603	MELAKA	29
2222603	MELAKA	51
2222603	MELAKA	45
2222603	MELAKA	55
2222605	MELAKA	65
2222605	MELAKA	63
2222605	MELAKA	57
2222605	MELAKA	65
2222607	MELAKA	77
2222607	MELAKA	74
2222607	MELAKA	71
2322607	MELAKA	66
2322610	MELAKA	78
2322610	MELAKA	79
2322610	MELAKA	77
2322610	MELAKA	62
2322613	MELAKA	78
2322613	MELAKA	82
2322613	MELAKA	79
2322613	MELAKA	59
2423616	BTG. MELAKA	69
2423616	BTG. MELAKA	76
2423616	BTG. MELAKA	83
2423616	BTG. MELAKA	59
2423614	BTG. MELAKA	73
2423614	BTG. MELAKA	81
2522614	BTG. MELAKA	69
2522614	BTG. MELAKA	70
2222604	PUTAT	
2222604	PUTAT	51
2222604	PUTAT	54
2322608	PUTAT	71
2322608	DURIAN TUNGGAL	87
2322608	DURIAN TUNGGAL	89
2322608	DURIAN TUNGGAL	85
2522615	DURIAN TUNGGAL	78
2522615	TAMPIN	89
2522615	TAMPIN	88
2522615	TAMPIN	84
2522615	TAMPIN	57

SNO	SUNGAI	WQI 00
2222601	MELAKA	73
2222601	MELAKA	56
2222601	MELAKA	50
2222601	MELAKA	47
2222603	MELAKA	51
2222603	MELAKA	57
2222603	MELAKA	48
2222603	MELAKA	69
2222605	MELAKA	58
2222605	MELAKA	53
2222605	MELAKA	57
2222605	MELAKA	56
2222607	MELAKA	64
2222607	MELAKA	66
2222607	MELAKA	56
2322607	MELAKA	63
2322610	MELAKA	72
2322610	MELAKA	76
2322610	MELAKA	77
2322610	MELAKA	77
2322613	MELAKA	85
2322613	MELAKA	82
2322613	MELAKA	87
2322613	MELAKA	89
2423616	BTG. MELAKA	76
2423616	BTG. MELAKA	78
2423616	BTG. MELAKA	81
2423616	BTG. MELAKA	82
2423614	BTG. MELAKA	76
2423614	BTG. MELAKA	78
2522614	BTG. MELAKA	83
2522614	BTG. MELAKA	81
2222604	PUTAT	77
2222604	PUTAT	78
2222604	PUTAT	74
2322608	PUTAT	78
2322608	DURIAN TUNGGAL	79
2322608	DURIAN TUNGGAL	75
2322608	DURIAN TUNGGAL	87
2522615	DURIAN TUNGGAL	85
2522615	TAMPIN	85
2522615	TAMPIN	85
2522615	TAMPIN	84
2522615	TAMPIN	84

APPENDIX B

SAMPLE OF VISIT SCHEDULED

SCHEDULE OF ENFORCEMENT VISIT

Enforcement Activities	No. of Visits		% Achieved	Note
	Plan	Achieved		
Manufacturing Industries	67			
Agro-based Industries				
Indah Water Konsortium	167	75	45	
Environmental Impact Assessment	16	11	69	
Scheduled Waste Premises	73	88	100	

APPENDIX C

STATUS OF COMPLIANCE FOR ALL THE INDUSTRIAL ESTATE LOCATED IN THE SUNGAI MELAKA CATCHMENT

LOCATION	TOTAL NO. OF INDUSTRIES	NO. & TYPES OF INDUSTRIES	NON-COMPLIANCE	% COMPLIANCE
1. KAW. PER. ALOR GAJAH (STANDARD A)	16	3 - ASAS MAKANAN 4 - ASAS GETAH 4 - ASAS KERTAS 4 - ASAS LOGAM 1 - ASAS ELEKTRONIK	1 3 0 0 0	75 25 100 100 100
2. KAW. PER. CHENG (STANDARD B)	9	3 - ASAS ELEKTRONIK 2 - ASAS KERTAS 3 - ASAS FAMASITIKAL 1 - ASAS MAKANAN	0 0 1 1	100 100 67 0
3. KAW. PER. KRUBONG (STANDARD B)	1	1 - ASAS KERTAS	0	100
4. KAW. PER. MALIM JAYA (STANDARD B)	4	4 - ASAS LOGAM	0	100
5. KAW. PER. TAMAN TASEK FTZ (STANDARD B)	15	1 - ASAS KERTAS 14 - ASAS ELEKTRONIK	0 0	100 100
6. KAW. PER. TAMAN TASEK UTAMA (STANDARD B)	2	1 - ASAS MINUMAN 2 - ASAS KERTAS	0 0	100 100
7. KAW. PER. AYER KEROH (STANDARD B)	15	5 - ASAS MAKANAN 3 - ASAS GETAH 1 - ASAS BESI 3 - ASAS KERTAS 1 - ASAS PLASTIK 2 - ASAS TEKSTIL	1 1 0 0 0 0	80 67 100 100 100 100
8. KAW. BATU BERENDAM (STANDARD B)	1	1 - ASAS MAKANAN	0	100
9. KAW. DURIAN TUNGGAL (STANDARD B)	2	1 - ASAS GETAH 1 - GETAH ASLI	0 0	100 100
10. KAW. TEBONG (STANDARD A)	1	1 - GETAH ASLI	0	100

Note:

Evaluation of % compliance were based on compound and court cases.

LOCATION	TOTAL NO. OF INDUSTRIES	NO. & TYPES OF INDUSTRIES	NON-COMPLIANCE	% COMPLIANCE
1. KAW. PER. ALOR GAJAH (STANDARD A)	16	3 - ASAS MAKANAN 4 - ASAS GETAH 4 - ASAS KERTAS 4 - ASAS LOGAM 1 - ASAS ELEKTRONIK	0 3 0 0 0	100 25 100 100 100
2. KAW. PER. CHENG (STANDARD B)	9	3 - ASAS ELEKTRONIK 2 - ASAS KERTAS 3 - ASAS FAMASITIKAL 1 - ASAS MAKANAN	0 0 0 0	100 100 100 100
3. KAW. PER. KRUBONG (STANDARD B)	1	1 - ASAS KERTAS	0	100
4. KAW. PER. MALIM JAYA (STANDARD B)	4	4 - ASAS LOGAM	0	100
5. KAW. PER. TAMAN TASEK FTZ (STANDARD B)	15	1 - ASAS KERTAS 14 - ASAS ELEKTRONIK	1 1	0 92
6. KAW. PER. TAMAN TASEK UTAMA (STANDARD B)	2	1 - ASAS MINUMAN 2 - ASAS KERTAS	0 0	100 100
7. KAW. PER. AYER KEROH (STANDARD B)	15	5 - ASAS MAKANAN 3 - ASAS GETAH 1 - ASAS BESI 3 - ASAS KERTAS 1 - ASAS PLASTIK 2 - ASAS TEKSTIL	1 3 0 0 0 0	80 0 100 100 100 100
8. KAW. BATU BERENDAM (STANDARD B)	1	1 - ASAS MAKANAN	0	100
9. KAW. DURIAN TUNGGAL (STANDARD B)	2	1 - ASAS GETAH 1 - GETAH ASLI	0 0	100 100
10. KAW. TEBONG (STANDARD A)	1	1 - GETAH ASLI	0	100

LOCATION	TOTAL NO. OF INDUSTRIES	NO. & TYPES OF INDUSTRIES	NON-COMPLIANCE	% COMPLIANCE
1. KAW. PER. ALOR GAJAH (STANDARD A)	16	3 - ASAS MAKANAN 4 - ASAS GETAH 4 - ASAS KERTAS 4 - ASAS LOGAM 1 - ASAS ELEKTRONIK	0 1 2 0 0	100 75 50 100 100
2. KAW. PER. CHENG (STANDARD B)	9	3 - ASAS ELEKTRONIK 2 - ASAS KERTAS 3 - ASAS FAMASITIKAL 1 - ASAS MAKANAN	0 0 0 0	100 100 100 100
3. KAW. PER. KRUBONG (STANDARD B)	2	1 - ASAS KERTAS	0	100
4. KAW. PER. MALIM JAYA (STANDARD B)	4	4 - ASAS LOGAM	0	100
5. KAW. PER. TAMAN TASEK FTZ (STANDARD B)	15	1 - ASAS KERTAS 14 - ASAS ELEKTRONIK	1 1	0 92
6. KAW. PER. TAMAN TASEK UTAMA (STANDARD B)	2	1 - ASAS MINUMAN 2 - ASAS KERTAS	0 0	100 100
7. KAW. PER. AYER KEROH (STANDARD B)	15	5 - ASAS MAKANAN 3 - ASAS GETAH 1 - ASAS BESI 3 - ASAS KERTAS 1 - ASAS PLASTIK 2 - ASAS TEKSTIL	1 0 1 0 0 0	80 100 0 100 100 100
8. KAW. BATU BERENDAM (STANDARD B)	1	1 - ASAS MAKANAN	0	100
9. KAW. DURIAN TUNGGAL (STANDARD B)	2	1 - ASAS GETAH 1 - GETAH ASLI	0 0	100 100
10. KAW. TEBONG (STANDARD A)	1	1 - GETAH ASLI	0	100

LOCATION	TOTAL NO. OF INDUSTRIES	NO. & TYPES OF INDUSTRIES	NON-COMPLIANCE	% COMPLIANCE
1. KAW. PER. ALOR GAJAH (STANDARD A)	16	3 - ASAS MAKANAN 4 - ASAS GETAH 4 - ASAS KERTAS 4 - ASAS LOGAM 1 - ASAS ELEKTRONIK	2 2 2 1 1	50 50 50 75 0
2. KAW. PER. CHENG (STANDARD B)	9	3 - ASAS ELEKTRONIK 2 - ASAS KERTAS 3 - ASAS FAMASITIKAL 1 - ASAS MAKANAN	0 0 0 0	100 100 100 100
3. KAW. PER. KRUBONG (STANDARD B)	2	1 - ASAS KERTAS	0	100
4. KAW. PER. MALIM JAYA (STANDARD B)	4	4 - ASAS LOGAM	0	100
5. KAW. PER. TAMAN TASEK FTZ (STANDARD B)	15	1 - ASAS KERTAS 14 - ASAS ELEKTRONIK	1 1	0 92
6. KAW. PER. TAMAN TASEK UTAMA (STANDARD B)	2	1 - ASAS MINUMAN 2 - ASAS KERTAS	0 0	100 100
7. KAW. PER. AYER KEROH (STANDARD B)	15	5 - ASAS MAKANAN 3 - ASAS GETAH 1 - ASAS BESI 3 - ASAS KERTAS 1 - ASAS PLASTIK 2 - ASAS TEKSTIL	1 1 1 1 0 0	80 67 0 67 100 100
8. KAW. BATU BERENDAM (STANDARD B)	1	1 - ASAS MAKANAN	0	100
9. KAW. DURIAN TUNGGAL (STANDARD B)	2	1 - ASAS GETAH 1 - GETAH ASLI	0 0	100 100
10. KAW. TEBONG (STANDARD A)	1	1 - GETAH ASLI	0	100

LOCATION	TOTAL NO. OF INDUSTRIES	NO. & TYPES OF INDUSTRIES	NON-COMPLIANCE	% COMPLIANCE
1. KAW. PER. ALOR GAJAH (STANDARD A)	16	3 - ASAS MAKANAN 4 - ASAS GETAH 4 - ASAS KERTAS 4 - ASAS LOGAM 1 - ASAS ELEKTRONIK	2 2 2 1 1	50 50 50 75 0
2. KAW. PER. CHENG (STANDARD B)	9	3 - ASAS ELEKTRONIK 2 - ASAS KERTAS 3 - ASAS FAMASITIKAL 1 - ASAS MAKANAN	0 0 0 0	100 100 100 100
3. KAW. PER. KRUBONG (STANDARD B)	2	1 - ASAS KERTAS	0	100
4. KAW. PER. MALIM JAYA (STANDARD B)	4	4 - ASAS LOGAM	0	100
5. KAW. PER. TAMAN TASEK FTZ (STANDARD B)	15	1 - ASAS KERTAS 14 - ASAS ELEKTRONIK	1 1	0 92
6. KAW. PER. TAMAN TASEK UTAMA (STANDARD B)	2	1 - ASAS MINUMAN 2 - ASAS KERTAS	0 0	100 100
7. KAW. PER. AYER KEROH (STANDARD B)	15	5 - ASAS MAKANAN 3 - ASAS GETAH 1 - ASAS BESI 3 - ASAS KERTAS 1 - ASAS PLASTIK 2 - ASAS TEKSTIL	1 1 1 1 0 0	80 67 0 67 100 100
8. KAW. BATU BERENDAM (STANDARD B)	1	1 - ASAS MAKANAN	0	100
9. KAW. DURIAN TUNGGAL (STANDARD B)	2	1 - ASAS GETAH 1 - GETAH ASLI	0 0	100 100
10. KAW. TEBONG (STANDARD A)	1	1 - GETAH ASLI	0	100

APPENDIX D

SUMMARY OF ALL DATA

Year 1996

Industrial Estate		Station No.	Average WQI	% of Compliance Status
1.	Alor Gajah	2322610	78.33	80
2.	Cheng	2322605	64.50	66.75
3.	Krubong	2322605	64.50	100
4.	Malim Jaya	2322603	54.60	100
5.	Batu Berendam (FTZ)	2322603	54.60	46
6.	Taman Tasek	2322604	41.0	100
7.	Ayer Keroh	2322604	41.0	91.17
8.	Batu Berendam	2322603	54.60	100
9.	Durian Tunggal	2322607	75.00	100
10.	Tebong	2322614	77.33	100

Year 1997

Industrial Estate		Station No.	Average WQI	% of Compliance Status
1.	Alor Gajah	2322610	74.00	85
2.	Cheng	2322605	59.50	100
3.	Krubong	2322605	59.50	100
4.	Malim Jaya	2322603	49.00	100
5.	Batu Berendam (FTZ)	2322603	49.00	46
6.	Taman Tasek	2322604	50.25	100
7.	Ayer Keroh	2322604	50.25	80
8.	Batu Berendam	2322603	49.00	100
9.	Durian Tunggal	2322607	68.00	100
10.	Tebong	2322614	69.50	100

Year 1998

Industrial Estate		Station No.	Average WQI	% of Compliance Status
1.	Alor Gajah	2322610	77.25	85.00
2.	Cheng	2322605	64.00	100
3.	Krubong	2322605	64.00	100
4.	Malim Jaya	2322603	58.25	100
5.	Batu Berendam (FTZ)	2322603	58.25	46.00
6.	Taman Tasek	2322604	53.75	100
7.	Ayer Keroh	2322604	53.75	80.00
8.	Batu Berendam	2322603	64.00	100
9.	Durian Tunggal	2322607	78.25	100
10.	Tebong	2322614	80.75	100

Year 1999

	Industrial Estate	Station No.	Average WQI	% of Compliance Status
1.	Alor Gajah	2322610	74.00	45
2.	Cheng	2322605	62.50	100
3.	Krubong	2322605	62.50	100
4.	Malim Jaya	2322603	45.00	100
5.	Batu Berendam (FTZ)	2322603	45.00	46
6.	Taman Tasek	2322604	52.75	100
7.	Ayer Keroh	2322604	52.75	93.50
8.	Batu Berendam	2322603	62.50	100
9.	Durian Tunggal	2322607	72.00	100
10.	Tebong	2322614	73.25	100

Year 2000

Industrial Estate		Station No.	Average WQI	% of Compliance Status
1.	Alor Gajah	2322610	79.25	45
2.	Cheng	2322605	62.25	100
3.	Krubong	2322605	62.25	100
4.	Malim Jaya	2322603	56.25	100
5.	Batu Berendam (FTZ)	2322603	56.25	46
6.	Taman Tasek	2322604	56.00	100
7.	Ayer Keroh	2322604	56.00	69
8.	Batu Berendam	2322603	56.25	100
9.	Durian Tunggal	2322607	75.50	100
10.	Tebong	2322614	76.75	100