International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Original Research Article

A Study on Assessing the Water Quality Status and Heavy Metal Content in Gali River (Sungai Gali), Kelantan State, Malaysia - A Pilot Survey

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Received: 16/09/2015 *Revised: 12/10/2015* *Accepted: 15/10/2015*

ABSTRACT

Background: Heavy metals constitute an important group of environmentally hazardous substances. Monitoring and assessment of river water has become environmental concern due to the contamination by mankind.
Aim and Objective: The aim is to study the pollution of Gali River, situated at Bachok area, Kelantan state, Malaysia wherein sea water is made to enter into an artificially created water way by dug for the purpose of the boat movements from different villages to sea for fishing activity. The objective of the study is to assess the water quality and heavy metals content (Fe,Pb,Cu,Mn,Zn) in Gali River during dry season(Feb 2013).
Methodology: The quality of water was studied at six selected points to represent different localities with varying anthropogenic discharge along the Gali River. The water quality was analyzed based on physico-chemical and biological parameters.
Result: The result of the analysis indicated that Gali River has been contaminated more with iron (7.34-14.40 mg/l) and the water quality is poor in terms of COD (24.67-145.3 mg/l), pH (3.3-7.3mg/l), DO (<1mg/l) and NH_3-N (1.97-2.83 mg/l) and the contaminated water is entering the sea.
Conclusion: It is concluded that the water quality of Gali River should be extensively monitored since deterioration of water quality was observed. Therefore, some sort of integrated river water management should be implemented.

Keywords: Environmental pollution, Water quality, Heavy metal content, Gali River, Kelantan state, Malaysia.

INTRODUCTION

Water is essential for life on earth. Water is a unique liquid, without it, life as we know is impossible. Water the "Elixir of Life" is facing a severe threat due to pollution. Water, due to its great solvent power, is constantly threatened to get polluted easily. The rate of water pollution has increased much more as compared to other fields of pollution due to the discharge of all sorts of obnoxious matter into it. [1] Water pollution refers to any type of aquatic contamination rendering the water body poisoned by toxic chemicals, which affect living organisms and all forms of life. A large number of physical and chemical wastes find their way into the aquatic environment and the pollutants are absorbed by fine grained organic particles that end up in the bottom

deposits. Heavy metals constitute an important group of environmentally hazardous substances. Monitoring and assessment of water has become environmental concern due to the contamination by mankind. [2] These heavy metals have a marked effect on the aquatic flora and fauna which through bio magnification enter the food chain and ultimately affect the human beings as well. Contamination of heavy metals in the environment is of major concern because of their toxicity and threat to human life and the environment. [3,4] Transition metals are essential for health, forming integral components of proteins involved in all aspects of biological function. However, in excess these metals are potentially toxic, and to maintain metal homeostasis organisms must tightly coordinate metal acquisition and excretion. [5] A study was conducted in well water of Kampung Aman, Telong and kndis in Bachok, Kelantan to determine the nitrate levels in drinking well water and found to be within the acceptable limit and health risk of respondents in these are were considered as low. [6] The water quality status of rivers in Malaysia has always been a cause for concern for various local authorities, government agencies as well as the public at large. Rivers are vital resource for life. The main causes of river pollution are rapid urbanization, arising from the development of residential, commercial, and industrial sites, infrastructural facilities and others.

Rivers in Malaysia are generally considered to be polluted with coherent examples such as Sg. Klang in Selangor state, Sg. Juru in Penang state and Sg. Segget in Johor Bharu state. From physical observation alone, one can deduce that something is not right with the current water quality condition of these rivers. From a scientific perspective though, it is still necessary to quantify the degree of pollution, in order to manage the pollution issues in a systematic and optimized fashion. [7] Literature review shows that no study was conducted to investigate the heavy metal content in the water of Gali River. Hence this pilot study was aimed to explore the heavy metal content and water quality on an artificially created shallow river named Gali River ("Sungai Gali" in Malay language), located at Bachok, Kelantan state, Malaysia wherein sea water is allowed to enter into an artificially created water way thus formed a river (Fig 1). Generally a river begins its life in hills or mountains, where rainwater collects and leaves the higher ground and enters flat plains and then river water has to find its way to the sea. At the end of its life, the river flows into a large body of water, such as an ocean, bay, or occasionally a lake to end its journey. The start of a river is called its source. The interesting feature of Gali River is that the source is sea i.e. South China Sea and the cause for the formation of this artificial Gali River were ascertained from the villagers. Sungai Gali [meaning of this Malay version is, "river formed by digging"] was formed by digging a water way and then allowed the sea water to this artificial dug path, for the movement of boats from different villages to the sea for fishing activity. It is said that the fishermen who are staying in different villages to a distance of about 15 km from their villages can access the sea directly from their homes for their fishing activity. Depending upon the effect of sea tidal currents, sea water enters and recedes the Gali River with stationary logged water in the water way. The breadth of the river is broad near the sea entrance (source) and gradually decreases i.e. converged like a > shape and the river ends at a point i.e. river end. An open garbage dumping site is present about 50' from the river end wherein garbage collected from various parts of Kelantan state is being dumped in. Because of this, the Gali River is being polluted continuously by this garbage dumping as well as the anthropogenic activities and the polluted water entering

the sea through the water way. Figure 1 show the bird's eye view of Gali River, garbage dumping site and sampling points (1 to 6).The study was to assess the influence of garbage dumping site located near the Gali River as well as the river water quality. The water quality was assessed by comparing with Water Quality Index norms of Malaysia Environmental Department. The quality of water from different stations was assessed and recorded.

Figure 1: Bird's eye view of Gali River (Sungai Gali) showing the artificial waterway

MATERIALS AND METHODS

Sampling activity: The quality of water was studied at six selected points/stations to represent different localities with varying anthropogenic discharge along the Gali River, starting from the source i.e. South China sea at Pantai Kandis (point 1), New bridge (point 2), Kandis jetty (point 3), near iron bridge (point 4), Kg. Beris Lalang (point 5) and near garbage dumping site (point 6), the end point of the river. The sample collection was conducted during February 2013 (dry season).Prior to sample collection, in situ water quality was measured using calibrated multisensory probe YSI model 550 MPS and in situ parameters include dissolved oxygen (DO) and pH. Using Van Dorn water sampler, water samples were collected about 15 to 30 cm below the water surface of the river from the designated points and preserved properly in a cool ice box and transported to analytical laboratory, Universiti Sains Malaysia, Kubang Kerian, Kelantan state, Malaysia for further analysis. Portable GPS was used to determine the coordinate each sampling station on location as presented in Table1:

The water samples collected in different sampling points in Gali River (point 1 to point 6) were subjected to heavy metal analysis through atomic absorption spectroscopic (AAS) method and the selected heavy metals include lead, copper, manganese, iron and zinc.

Quality control: The analytical data quality was guaranteed through the implementation of laboratory quality assurance and quality control methods, including the use of standard operating procedure, calibration with standards, analysis of blank reagents and analysis of replicates. The analysis of all samples was carried out in triplicates, and the results were expressed as the mean of them.

Table 1: Description of Gali River sampling location in Bachok, Kelantan state, Malaysia

Location	Sampling points					
	1 PantaiKandis	2 New Bridge	3 Kandis Jetty	4 Iron bridge	5 Kg. BerisLalang	6 Near garbage dumping site
Latitude	$05^0$57.461 N	$05^0$57.414 N	$05^0$57.166 N	$05^0$56.336 N	$05^0$56.174 N	$05^0$55.875 N
Longitude	$102^0$26.972 E	$102^0$26.824 E	$102^0$26.378 E	$102^0$24.804 E	$102^0$24.678 E	$102^0$24.662 E

RESULT AND DISCUSSION

Table 2: presents the physico-chemical parameters of water samples collected along the Gali River between the source [point 1 (near sea)] and river end (point 6). The color of water was found to be muddy in points 1 and 2 and brownish in points 3-6.The odor of water in points 5

and 6 was disagreeable and obnoxious. The water quality was analyzed based on physico-chemical and biological parameters viz. pH, Total suspended solids TSS (mg/L), chemical oxygen demand COD (mg/L), ammoniacal nitrogenNH_3-N (mg/L) and biochemical oxygen demand BOD(mg/L).

Table 2: The physico-chemical characteristics of Gali River water in different sampling points (1 to 6)

Parameter	Sampling points	(Mean value)	SD
pH	1	7.3	0.02
	2	6.9	0.03
	3	6.3	0.03
	4	3.5	0.04
	5	3.3	0.05
	6	3.3	0.02
Ammoniacal nitrogen NH_3-N (mg/L)	1	2.27	0.06
	2	1.97	0.15
	3	2.03	0.15
	4	2.73	0.12
	5	2.83	0.06
	6	6.20	0.35
Chemical Oxygen Demand, COD (mg/L)	1	24.67	1.15
	2	26.0	1.20
	3	39	1.17
	4	132.22	1.53
	5	138.33	2.70
	6	145.33	2.91
Dissolved Oxygen, DO (mg/L)	1	0.17	0.03
	2	0.25	0.03
	3	0.35	0.03
	4	0.33	0.02
	5	0.43	0.03
	6	0.31	0.02
Biochemical oxygen demand, BOD (mg/L)	1	0.84	0.02
	2	0.94	0.03
	3	1.02	0.06
	4	1.17	0.08
	5	1.52	0.11
	6	1.86	0.15
Total Suspended solid, TSS (mg/L)	1	26.40	0.10
	2	18.93	0.15
	3	12.70	0.10
	4	27.67	0.06
	5	19.87	0.11
	6	25.33	0.15
Physical appearance and odor		**Color of water samples**	**Odor**
	1	clear	no characteristic odor
	2	clear	no characteristic odor
	3	Light brownish	no characteristic odor
	4	Light brownish	muddy
	5	brownish	muddy
	6	Dark brownish	unpleasant

No of water samples collected in each point = 3

Table 3: Comparison of Gali water quality with Malaysian Water Quality Index classification (MWQI)

Para-meters	Unit	Gali river water quality [Mean] – Present study						MQI Classes				
		1	2	3	4	5	6	I	II	III	IV	V
pH		7.3	6.9	6.3	3.5	3.3	3.3	> 7	6 - 7	5 - 6	5	< 5
DO	mg/l	0.2	0.2	0.4	0.4	0.3	0.3	> 7	5 - 7	3 - 5	1 - 3	< 1
BOD	mg/l	0.8	0.9	1.0	1.2	1.5	1.9	< 1	1 - 3	3 - 6	6 - 12	> 12
COD	mg/l	24.7	26.0	39.0	132.2	130.3	145.3	< 10	10 - 25	25 - 50	50 - 100	> 100
TSS	mg/l	26.4	18.9	12.7	27.7	19.9	25.3	< 25	25 - 50	50 - 150	150 - 300	> 300
NH_3-N	mg/l	2.3	2.0	2.0	2.7	2.8	6.2	< 0.1	0.1 - 0.3	0.3 - 0.9	0.9 - 2.7	> 2.7
Status								Clean	Slightly Polluted	Slightly Polluted	Polluted	Polluted

Source: www.wepa-db.net/policies/state/Malaysia/river.htm

A. pH Analysis: It is aware that pH is an important indicator to access water quality. The result of the investigation shows that pH in Gali River varied between 3.3 and

7.3 with a mean pH value of 5.1. The mean pH value declined gradually from point 1 to point 6 showing that the acidity gradually increased from the point 1, near sea to point 6, near garbage dumping site. The pH of Gali river water at point 1 was neutral to alkaline (7.3) and the acidic at point 6 which is in the order of 7.3< 6.9 < 6.3 < 3.5 < 3.3 < 3.3. The high acidity at point 6 is due to the effect of garbage dumping site, perhaps contained acidic substances. Table 3: shows the comparison of water quality between Gali River and Malaysian water quality index classification. According to MWQI, the quality of Gali River water in these points was categorized as class II and V.

B. Biochemical Oxygen Demand (BOD) Analysis: Biological oxygen demand (BOD) is the amount of oxygen required by bacteria to stabilize organic matter under aerobic conditions. The BOD test involves the determination of oxygen uptake by bacteria under standard conditions which is five days incubation at 20 ºC. The concentration of BOD in water sample can determine the degree of pollution caused by microorganisms through biodegradation. According to MWQI, if the BOD concentration is more than 1 ppm, the water is considered polluted. The result of BOD in Gali River showed that the values are gradually increased from point 1 to point 6 which is in the order of 0.84> 0.94> 1.02 > 1.17 > 1.52 > 1.86. The result of the investigation shows that Gali River water in all points was categorized as Class I and II.

C. Chemical Oxygen Demand (COD) Analysis: Chemical oxygen demand (COD) test predicts oxygen requirement during the decomposition of organic matter and the oxidation of inorganic chemicals. Theoretically, if COD concentration is higher (10-100 ppm), the water is considered as polluted. The analysis result of BOD in Gali river water showed that the values gradually increased from point 1 to point 6 which is in the order of 24.7 > 26.0 > 39.0 > 132.2 > 130.3 > 145.3. The concentration of COD at points 3-6 is comparatively higher than points 1 and 2 and this may be due to higher decomposition of organic and inorganic contaminants, dissolved or suspended in water. According to MWQI, the quality of Gali River water in all points was categorized as class III – V.

D. Total Suspended Solid Analysis: Suspended solids (SS) in water consist of inorganic and organic particles. Inorganic particles such as clay slit and other soil constituent and organic material such as plant fibers and biological solids like algae, bacteria, plankton are found in water. Higher inorganic and organic particles in river contribute higher of Total suspended solid (TSS) in river as well can effect turbidity in river water. As the river pollution increases, correspondingly the TSS value also increases. [8] According to classification of Malaysian Water Quality Index, points 2, 3 and 5 are categorized as class I and points 1,4 and 6 are categorized as class II. The result of TSS loading in river water varies depended on the level of runoff due to low and high tide on the sampling day.

E. Dissolved Oxygen Analysis: Oxygen is the most well established indicator of water quality. DO is an essential parameter for the survival of all aquatic organisms. DO analysis presents the amount of oxygen is available in river water. Hence, low DO, high BOD and COD rapidly decrease the oxygen content of the river making it difficult for the fish and other valuable aquatic fauna to survive. Oxygen concentrations vary with the volume and velocity of water flowing in a stream. The colder the water, the more oxygen it can hold. [9] Table 2: shows that dissolved oxygen varied between 0.2 and 0.4 mg/l in water samples collected in different points and as regards to the Malaysian Water Quality Index system, the tributaries can be classified into Class V.

F. Ammoniacal Nitrogen (NH_3-N) Analysis: Ammoniacal nitrogen NH_3-N indicates nutrient status, organic enrichment and health of water body. It commonly forms as organic, ammonia, nitrate, nitrite and gaseous nitrogen. [10] The higher the value of ammoniacal nitrogen, more the river water polluted. The investigation revealed that the values in point 1 to point 6 are in the order of 2.3, 2.0, 2.0, 2.7, 2.8 and 6.2 mg/L respectively. Regarding the pollution level, points 1,2 and 3 come under class IV and others come under class V. Anyhow both classes IV and V are considered as polluted status that may degrade the aquatic status.

G. Heavy metal analysis: Contaminants such as heavy metals, phosphorous, pesticide and polycyclic aromatic hydrocarbons, can be taken up and concentrated in sediments and suspended matter in aquatic systems. [11] The metals are classified as "heavy metals" if in their standard state they have a specific gravity of more than 5 g/cm^3. As heavy metals are not decomposed biologically, level of these metals, beyond recommended limit, may exist in the river for quite a long distance and it may lead to the long term health-related problems to the people and communities. Heavy metals are the abundant forms of pollution in Malaysia either in the forms of solid or liquid. With the vast industrialization and economic development in coastal region, heavy metals are continuing to be introduced to the estuarine and coastal environment which eventually end up into the river, runoffs and land based area. Metals diffuses into the aquatic environment will settle down and be incorporated into sediments together with organic matters, Fe/Mn oxides, sulfides, and clay. Contaminated sediment can cause lethal and sub-lethal effect in benthic and other sediment associated organisms. [12] The water samples collected in different sampling points of GaliRiver were analyzed and presented in Table 4:

Table 4: Concentrations of various heavy metals in GaliRiver water.

Heavy metals	Sampling points	Heavy metal concentration in river water samples [mean] (mg/L)
Fe	1	7.34
	2	7.87
	3	8.31
	4	8.81
	5	9.18
	6	14.40
Pb	1	0.46
	2	0.67
	3	0.62
	4	0.67
	5	0.76
	6	0.78
Cu	1	0.03
	2	0.03
	3	0.04
	4	0.05
	5	0.05
	6	0.05
Mn	1	0.10
	2	0.12
	3	0.12
	4	0.11
	5	0.11
	6	0.15
Zn	1	0.20
	2	0.16
	3	0.20
	4	0.22
	5	0.30
	6	0.30

No of water samples collected in each point = 3

The iron concentration is found to be higher (7.34 – 14.40 mg/l) than lead, copper, manganese and zinc. This finding is in accordance with the findings in a study conducted at AmparTenang open landfill area, Selangor state, Malaysia. [13] The metal concentrations of iron, lead, copper, manganese and zinc found varied from point 1 to point 6, comparatively higher at point 6 (near the garbage dumping site) and lower at point 1 (near the sea entry). This showed that heavy metals still attained in the river water that samples have been tested. The higher value of water sample collected closest with garbage dumping site at the point 6 shows that the movement of leachate from dumping site direct to river bring together more heavy metal as pollutant. Figure 2 presents the line graphs showing the concentration of various metal ions in

water collected in six different sampling points at Gali River. The study was conducted during summer season. Researchers indicated that meteorological changes such as rain fall having significant negative influence. [14]

During the sample collection, it was observed the river water was used for little agricultural activity near the river area. The garbage dumping site area seemed to contribute to high iron content, BOD and COD value because of leachate which still produced through decomposition process although this site here for years. Near the garbage dumping site, the water was found to be dark brownish in color indicated heavy metal load and deteriorated water quality. The heavy metal load caused toxicity on the water body which varies sharply at different sampling points.

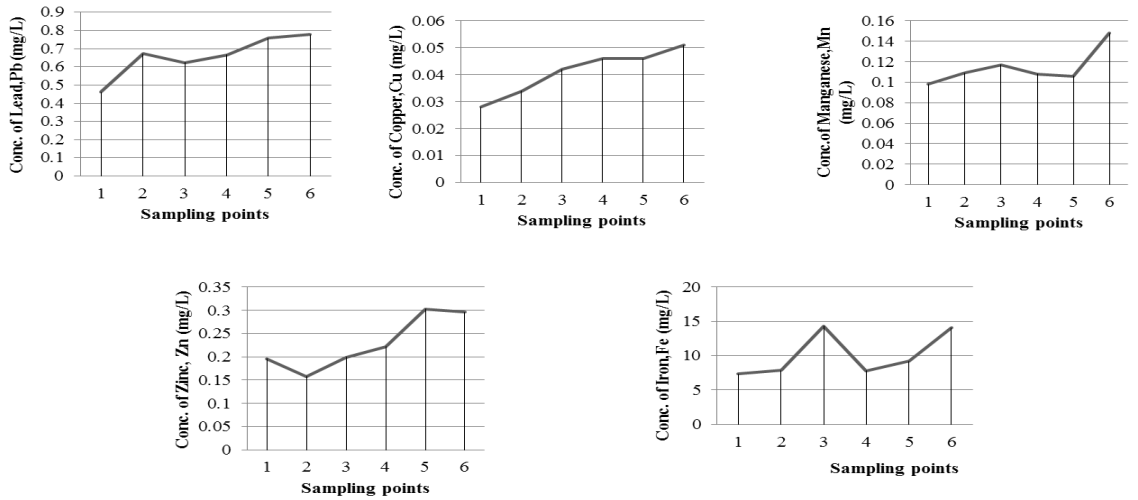

Figure 2: Line graphs showing the various metals ion concentration in different sampling points at Gali River water

CONCLUSION

It is concluded that Gali River is contaminated with heavy iron metal, even though other metal concentrations are not alarming in addition to poor quality of water in terms of COD, pH, DO and NH_3-N. Some effective management is needed to tackle leachate problems and to reduce the disfavor smell from the garbage dumping site. Therefore, continuous monitoring and comprehensive sampling are necessary to ensure the river's status in the long term. Hence it is suggested that detailed future study may be conducted in the Gali River.

The finding of this research was presented in"2nd International Environment & Health Conference- 2014 held at Kota Bharu, Kelantan state, Malaysia on 27, 28 August 2014.

The authors did not receive any specific funding for the aforementioned research.

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How to cite this article: Moorthy TN, AbShattar SFB. A study on assessing the water quality status and heavy metal content in Gali River (Sungai Gali), Kelantan state, Malaysia - A pilot survey. Int J Health Sci Res. 2015; 5(11):292-299.

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