2012 International Conference on Environmental Science and Technology
IPCBEE vol.30 (2012) © (2012) IACSIT Press, Singapore

Monitoring Stormwater Quality of Potential ex-Mining Ponds

Husna Takaijudin [1+], Sheikh Ahmad Kamil Sheikh Ahmad Tajuddin [1] , Ahmad Mustafa Hashim [1] and Syukriyah Ishak[1]

[1] Department of Civil Engineering, Universiti Teknologi PETRONAS, 31750 Tronoh, Perak, Malaysia

Abstract. Ex-mining ponds in Malaysia remain unproductive and improperly used. Thus, they have a potential to be upgraded as storage as well as treatment systems. The aim of this paper is to assess the potential of ex-mining pond in treating some of the effluent from various types of industrial areas. Two ex-mining ponds at Taiping were selected as a case study. Water sampling, in-situ testing and laboratory experimental work were conducted within 6 months monitoring. Results found that four (4) parameters (DO, COD, BOD, and NH_3-N) are most significant to the water quality. According to the result, the abandoned ponds in the study area are polluted. However, Pond B has potential to be used for water supply and further treatment required. However, more polluted Pond A compared to Pond B can be used for irrigation purposes. It is recommended to integrate the ponds with other treatment facilities such as infiltration trench or bioswales to enhance their performance.

Keywords: ex-mining pond, water quality, stormwater, monitoring system

1. Introduction

Tin mining had been one of the major activities in Malaysia since 1820. It started after the arrival of hardworking Chinese immigrant mostly Cantonese and Hakka who were the manpower of the activities. Perak produced about 63% of tin industry which was the largest tin producer in Malaysia. Taiping is the first town where tin mining was being commercialized and by 1883, Malaysia became the largest tin producer in the world. It was reported that mining activities brought significant impact to the environment due to high concentration of heavy metals (Class IV) in study area with majority of water quality parameter was classified in Class III in terms of Malaysian Interim Water Quality Standards (INWQS) [1].

Nowadays, the tin industry has become unproductive. The mining ponds in Malaysia which existed many years ago are now abandoned due to lack of planning. Some of them had been utilized as illegal landfill site. Research showed that only 4730 ha (4.2%) of ex-mining land has been operated for agriculture and 5.5% for other uses [2]. There were some environmental issues regarding the abandoned mining ponds. The abandoned mining tools, building and structures may contain harmful contaminants such as heavy metal, engine oil spillage to the pond and other compounds. This phenomenon contributed to the water pollution either surface water or groundwater. Thus, a proper guideline was produced to keep this sensitive area safe to the environment. Some of the abandoned mining ponds have been conserved and some of them have been upgraded to be recreational areas [3].

The excessive uptake of heavy metals in the agricultural product cultivated on tin tailings has rendered unsuitable site for food crop production. Some of the heavy metals namely cadmium, mercury, arsenic and lead found in the fruits and vegetables produced from the ex-mining land have exceeded the permissible limits for human consumption[4]. The pond and swales contain more concentration of heavy metals because of the longer accumulation of time compared to street sweepings [4]. The metals are Aluminium, Arsenic,

+ Corresponding author. Tel.: +6053687354; fax: +6053656716.
E-mail address: husna_takaijudin@petronas.com.my.

Barium, Beryllium, Cadmium, Chromium, Copper Lead, Mercury, Nickel, Silver and Zinc [4]. Flooding of a mine can result in the: (1) dissolution of accumulated pyrite-oxidation products, (2) reduction in the access of oxygen to the subsurface with a corresponding decrease in the pyrite oxidation rate, and (3) progressive dilution of initially acidic water by alkaline groundwater inflows. Such processes could account for gradual improvement in surface-water quality that has been on-going for decades throughout the region [5]. The utilization of abandoned mining pond is predicted to be the best of retention facilities due to its natural characteristics. Thus, the consideration of integrating ex-mining pond as retention pond is cost effective. The analysis of the mining pond were considered for both quantity and quality analysis. The storm event of 10 year Annual Recurrence Interval (ARI) was used for minor pond design and 50 years ARI for major design [6]. The main purposes of water quality assessment are to identify potential ponds that can be used as infrastructure i.e. runoff treatment facilities or developed as recreational areas. Secondly, to determine the status of ex-mining pond and finally, to identify the cause and problem regarding the water quality issues [7].

The aim of this paper is to classify the water quality of abandoned mining pond based on INWQS. It is also addressing second objective which to identify the potential of abandoned mining pond to be upgraded as one of the stormwater treatment facilities.

2. Material and Methods

The study site encompasses the entire catchment area of Larut Matang and Selama and situated about 10 km from North-South Expressway (PLUS) Toll. The area of Zone 1 covered the industrial areas at Kamunting Raya and while Zone 2 refer to the old industrial area at Kamunting which about 10 km from Zone 1 (Fig. 1 and Fig. 2). Both zones were chosen to identify the potential ex-mining pond (Pond A and Pond B) on their performance in runoff treatment. Both ponds were selected due to its location at the downstream from catchment areas. Thus, stormwater runoff from drainage areas can be discharged gravitationally before it reached to the nearest stream Sungai Air Putih.

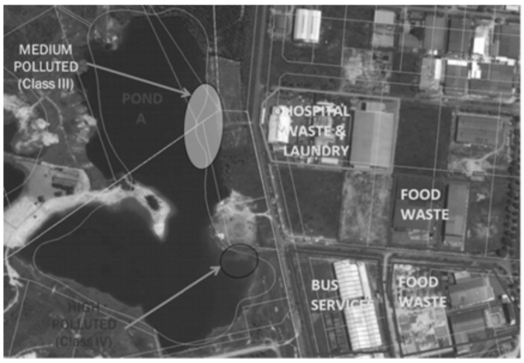

Fig. 1: Aerial view of Pond A

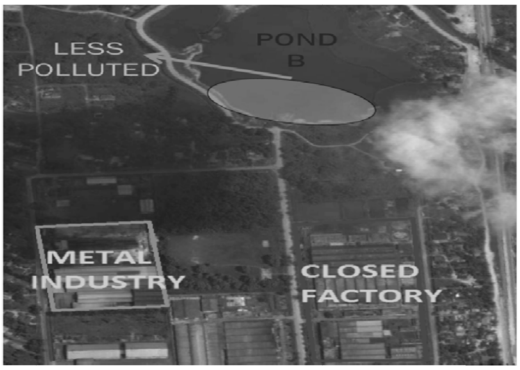

Fig. 2 : Aerial view of Pond B

Monitoring is often designated as an integrated activity for evaluating the physical, chemical and biological characters of water in relation to human health, ecological conditions and designated water uses [6]. Common constraints include site accessibility and sample collection logistics must be factored into initial design of monitoring program. In this project, the pollutant discharges have been identified from various types of industries especially in Zone 1 such as food industries, clinical waste disposal and laundry.

Five (5) points were selected for analysis; three (3) points at Pond A and two (2) points at Pond B. Pond A is located near laundry industry. Some of the factories were closed and Pond B is located quite far from the factories. Thus, Pond B received lesser industrial pollutants compared to Pond A. There is a mixed industrial discharge from the natural drain which enters to a mining pond B. Based on interview with local people, flash flood always happened during heavy storm at Pond B. The runoff from construction site flow rapidly due to different elevation of construction site and the surrounding area is significantly higher. Thus, the local authority has taken proactive step when they have provided a pipe culvert to cater the overflow from Pond B and divert to the river. The categories of sampling points are tabulated in Table 2.

Table 2: Sampling Point Categories.

Sampling Point	Description
1	Laundry industry. The outflow from internal drainage enters to a road side drain and directly discharged to the ex-mining pond.
2	Mixed industrial discharge from road side drain.
3	Mixed discharge from residential and industrial areas which contribute to Pond B
4	Pond B (Kamunting Pond)
5	Culvert which crossing the road. The food waste has been channeled to this culvert and finally entered Pond A.

In-situ testing was conducted at two different session; the first session started 11 February 2011 until 13 February 2011 (dry season)while the second session began from 18 April 2011 to 20 April 2011(wet season). Water samples were collected from each point using grab water sampling method. It was taken 3-4 times a day and the weather for specified times have been recorded. Sample No.5 was collected during second session only.

The pH, Chemical Oxygen Demand (COD), ammoniacal nitrogen (NH_3-N), dissolved oxygen (DO), were measured during these two sessions. Some factors need to be considered such as site accessibility conditions, travel time and other influence on monitoring water quality parameters. Besides, Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS) experiments were conducted in the laboratory since it required a period of time to obtain the results. 18 water samples were collected within 3 days in the first session and 27 samples in second session. As for the last day of the site investigation for each month, the water samples were taken to the laboratory.

The pH of samples was determined using pH meter. Turbidity was measured using a turbidimeter. Higher percentage of total suspended solids in the water results in higher turbidity. COD, Ammonia Nitrogen, Nitrate and Total Phosphorus were determined using HACH Spectrophotometer. For TSS test, pore size 47 mm micro-fiber filter disc was used.

The results have been analyzed by statistical analysis. Then, it is followed by comparing the result with the INWQS for Malaysia using Water Quality Index (WQI) calculation using Eq. (1).

$$WQI = (0.22\ SIDO) + (0.19\ SIBOD) + (0.16\ SICOD) + (0.15\ SIAN) + (0.16\ SISS) + (0.12\ SIpH) \quad (1)$$

3. Result and Discussion

There were six (6) main parameters which examined to monitor water quality of the ponds. Table 1 and 2 list the summary of water quality parameter for both ponds during first and second session respectively. It is also indicate the performance of each pond by comparing the results of each parameter for Pond A and Pond B.

During session 1, the average DO values were varied from 0.7- 3.5 mg/L. However, the values were observed significantly higher where the values within the range of 2-4.4mg/L during session 2. The main possible reason was heavy rainfall occurred during session 2. Thus, this condition might increase the volume of water which subsequently increases the oxygen amount in the surface runoff and also pond itself. Pond B performed well during session 2 (wet season) as compared to session 1 (refer Table 1 and 2). Based on the observation, the pond received the discharge mostly from the nearest village and construction site. And presumably the water at this location was not polluted by the industrial effluent due to the location was too far and most of the factories here were not in operation.

Table 1 : Water quality parameters during first session monitoring.

Parameter	Arithmetic Mean		Median		SD		CV		Minimum		Maximum	
	Pond A	Pond B	Pond A	Pond B	Pond A	Pond B	Pond A	Pond B	Pond A	Pond B	Pond A	Pond B
DO (mg/L)	2.47	1.86	2.87	1.78	1.66	1.46	1.49	1.27	0.11	0.05	4.59	4.57
BOD (mg/L)	20.94	4.16	21.03	3.94	19.02	1.80	1.10	2.32	2.28	2.22	40.08	6.12
COD (mg/L)	267.09	35.86	67.00	63.00	326.62	32.84	0.82	1.09	48.00	-36.0	1022.00	100.00
NH_3^-N (mg/L)	7.69	3.31	2.50	2.43	8.47	3.27	0.91	1.01	1.25	0.03	25.00	8.25
pH (mg/L)	7.55	6.90	7.38	6.92	0.47	0.20	15.99	41.33	7.04	6.64	8.63	7.18

Table 2: Water quality parameter during second session monitoring

Parameter	Arithmetic Mean		Median		SD		CV		Minimum		Maximum	
	Pond A	Pond B	Pond A	Pond B	Pond A	Pond B	Pond A	Pond B	Pond A	Pond B	Pond A	Pond B
DO (mg/L)	2.72	3.99	2.69	3.65	1.26	1.00	2.17	1.00	0.39	3.09	4.59	4.57
BOD (mg/L)	6.99	2.92	8.19	2.82	2.96	1.80	1.10	2.32	2.28	2.22	40.08	6.12
COD (mg/L)	92.48	28.39	63.00	13.50	52.37	21.94	1.77	1.29	36.00	7.00	206.00	64.00
NH_3^-N (mg/L)	1.72	1.15	1.52	0.61	0.62	1.09	2.81	1.01	0.11	0.03	3.13	3.39
pH (mg/L)	6.91	6.88	6.93	6.90	0.20	0.23	15.99	41.33	6.49	6.37	7.25	7.40

The constituent of BOD was normally caused by sewage effluents or process effluent from particular industries. Pond A was significantly affected by direct discharges of food waste effluent from nearest factories. The average value of BOD was up to 38 mg/L during the 1^{st} session and is beyond INWQS limit (>12 mg/L) for Class V. However, during session 2, the values reduced approximately to 10 mg/L due to more oxygen supplied during heavy rainfall. Besides, Pond B produced lower BOD level compare to Pond A where the percentage differences are 93.28 % and 77.85% for both sessions respectively. Based on Table 1 and 2, the arithmetic mean and median of BOD values were both in better agreement where the values were quite closed each other during first session compared to second session.

COD is the most significant parameter where it represents the organic loading and oxygen demand. Pond B showed better performance as compared to Pond A where the values differences are 84% (session 1) and 68 % (session 2). The main possible cause was suspected to be food waste that was directly discharged to the Pond A through the existing channel (concrete drain and earth drain) at the pond inlet. Besides, the pond was near the construction site where construction waste accumulated and dumped at the pond inlet. These values indicated that the water quality at pond B was significantly better than pond A. However, the negative values at Pond B affected the value of Coefficient of Variance (CV) and Standard Deviation (SD) where the arithmetic mean value was lesser than SD value. Thus, it indicated that the value was not valid.

The ammonium level depends on the water temperature and pH. At high temperature and pH, a greater number of ammonium ions are converted into ammonia gases. It has resulted the increment of toxicity level in the freshwater. NH_3^-N causes significant impact to the water quality of the pond. Pond B presented a better performance compare to Pond A. The values exceeded 0.3 mg/L. Pond A achieved the highest mean value of 7.69mg/L respectively. However, it was suddenly dropped during session 2 due to existence of heavy rainfall that may dilute all the nutrient quickly. According to INWQS, the discharge limit for NH_3^-N should not exceed 2 mg/L. SD values for all locations provide good data except at Pond A which was slightly higher (8.47mg/L) for the first session. The mean and median values also illustrate that the data for each location are reliable since the values were closed.

TSS analysis was presented in Fig. 3. Pond A has higher TSS content as compared to Pond B for both sessions. This condition most likely due to pond A received the runoff from heavy industrial areas that still actively operating at this Industrial Park whereas the effluent that discharge to pond B came from the areas where majority of the industries at Kamunting were closed and only a few factories were operated there. It was caused by the construction activities as well as heavy food waste discharge heavily in this particular area. The significant impact of this situation have caused the water depth became shallower and the water to be highly turbid and murky.

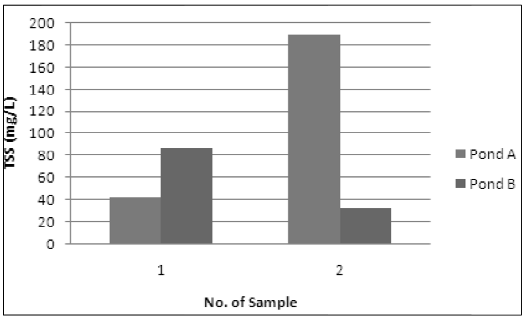

Fig. 1: TSS value for Pond A and B during both sessions

The study found that pH values are in the good ranges7-8. Referring to the Table 1 and 2, pH values have a good agreement with small value of SD.

The biological life can sustain at suitable range of pH typically from 6 to 9 [8]. Other researchers stated that the best pH range for sustenance of aquatic life is between 7.0 and 7.6 [9]. On site observations showed many species of fishes, algae, and lotus found in the pond. Based on the overall result, WQI have been calculated using the Eq. (1) for each sample as listed in Table 3. Majority of the samples are in Class IV except for location Pond B (Class III), having better quality as compared to others. Pond B can be used for water supply but need further treatment on it. Pond A, where it is the discharge from food waste and construction site contributed more pollution to the environment which cause the water quality drop to Class V. Pond A required extensive treatment where it can be used only for irrigation purposes. Thus, it can be classified as polluted area.

where WQI is Water Quality Index; SI is Sub Index for each parameter.

Table 3: The classification and water quality status for each sampling points.

Sample	WQI	CLASS	WQ Status
1	50	IV	Polluted
2	47.5	IV	Polluted
3	65	III	Slightly Polluted
4	29	V	Polluted
5	44	IV	Polluted
AVERAGE	51.4	IV	Polluted

4. Conclusion

The study summarized that the overall water quality falls under Class VI based on INWQS where Kamunting Raya pond is heavily polluted. Result found that the discharge from industrial disposal bring significant impact to the stormwater quality. Based on the result, Pond A has received more pollutants as compared to Pond B. Pond A is situated nearby the industrial park. Thus, the effluent is easily flowing through the existing drainage system and finally discharges to the pond. Pond B was not disturbed by the industrial effluent due to most of the factories was not operational. Besides, the pond is far from the industrial areas. Thus, the pond was not affected by the effluent from the industry. Results found that there were four (4) parameters (DO, COD, BOD and NH_3-N) which are most significant to the water quality. It was supported by the statistical analysis where most of the values were reliable and within good agreement. However, it can be seen that the quality of water was improved during and after the rain because it will increase the amount oxygen level in the pond. Industrial effluents need to be treated before it enters to the natural water course. Thus, it is recommended to propose mitigation measures to cater industrial waste disposal. Efficient management of waste effluent disposal and provision of sufficient buffer between industrial and residential areas are essential to minimize pollution and hazards. Monitoring program for natural water resources need to be conducted consistently to provide the relevant water quality for assessment and compliance officers to enhance crucial decision making. These ponds have the potential to be upgraded as retention pond with good landscaping and it is also suitable for recreational areas.

5. Acknowledgements

Funding is from Short Term Internal Research Fund (STIRF) No. 11/10.11 provided by Universiti Teknologi PETRONAS. This research was supported by local authorities Majlis Perbandaran Taiping (MPT) especially Mr. Tun Tajiri Baharum and his staff. Special thanks to Mr. Zaaba B. Mohammad and Ms. Yusyawati Yahaya of Universiti Teknologi PETRONAS for sharing their insightful understanding, profound knowledge, assistance and criticisms throughout the project.

6. References

[1] M.A. Ashraf, M. M. Study of Water Quality and Heavy Metals in Soil and Water of Ex-mining Area Bestari Jaya, Peninsular Malaysia. *Int. J. Basic & Appl. Sci.* 2008, **10** (3): 7-16.

[2] Y. Chan. The Mining Land- An Overview of the Current Situation in Peninsular Malaysia. *Presented at the Seminar on Ex-Mining Land and BRIS Soils: Prospects and Profit, 15-16 October 1990*, Kuala Lumpur. pp. 17.

[3] Y. Ibrahim. Sustainable Re-Use of Ex-Mining Land. *Planning in Green Review ,* 2010, **07** (01): 13-21.

[4] C.A. Cravotta III, R.A. Brightbill, and M.J. Langland. Abandoned Mine Drainage in the Swatara Creek Basin, SouthernAnthracite Coalfield, Pennsylvania, USA: 1. Stream WaterQuality Trends Coinciding with the Return of Fish. *Mine Water Environ*. 2010, **29**: 176-199.

[5] C.K. Chang, A. G. Rehabilitation of Ex-Mining Pond for Integrated Stormwater Management. *11th International Conference on Urban Drainage*, Edinburgh, Scotland. 2008: 1-10.

[6] J. Liebens. Heavy metal contamination of sediments in stormwater management systems: the effect of land use, particle size, and age. *Environ. Geol.* 2010, **41** (3-4): 341-351.

[7] H Takaijudin, A.M. Hashim, and N. Rauf . Assessment on Pollutant Removal of Interconnected Wet Detention Pond. *Environ. Sci.* 2011, **10** (3): 324-329.

[8] T. Khattak, N. Bhatti, and G. Murtaza, (2005). Evaluation of ALgae from the Effluent od Dandot Cement Company, Dandot, Pakistan. *J.Appl. Sci. Environ. Manage.*2005, **9** (1), 14-149.

[9] Metcalf, and I. Eddy. *Wastewater Engineering:Treatment and Reuse* (4th ed.). New York: Mc Graw-Hill Companies. 2004.