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Centralized or Decentralized – Best Project Option (BPO) for Melana River Basin, Malaysia

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ABSTRACT

This study focuses on four options as a mandatory improvement of existing sewage treatment plants (STPs) in Melana River basin, Malaysia. In general, the wastewater usually managed through a centralized system in the STP. A network of sewer pipes carries the wastewater from houses and commercial facilities to a central municipal treatment plant where the combined flows are treated. The treatment systems that commonly being used are Individual Septic Tank (IST) and Imhoff Tank (IT). The analysis of steady state mass balance carried out showed that the existing STPs could achieve poor in-standard effluent discharge limit, if no immediate action is taken. Therefore, four options have been proposed in order to comply with the Water Quality Index (WQI). The options are; establishment of new treatment plant, improvement of oxidation pond, implementation of separate system and new centralized wastewater treatment.

Keywords: *Melana river, Water management, Centralized system, Water Quality Index (WQI)*

1. INTRODUCTION

Melana River is located at Johor, Malaysia approximately between 1º30' (N) to 1º35' (N) and 103º35' E to 103º45' E. The river basin being occupied by catchment, covering an area of 21.12 km^2, with a length of 13.5 km. The catchment includes settlement areas such as Taman Sri Pulai, Taman Pulai Utama, Taman University, Taman Ungku Tun Aminah, Taman Teratai, and Taman Desa Skudai. Melana catchment has undergone rapid changes since last twenty years with the development of new residential areas, palm oil industries, roads, clearing land for timber or agriculture etc. The land use practices such as housing developments and water diversions may have environmental consequences that will substantially affect stream even when the land use is not directly associated with stream [1].

The Indah Water Consortium's (IWK) report states that most of the existing STPs are said to reach the design capacity [2] , but in practice they hardly meet higher standard set by Water Quality Index (WQI). Even though some of the existing treatment plants did not exceed the design capacity, the effluent discharge sometimes does not comply with the standard. This is because STP is already decreasing in its functionality and poor maintenance. Based on the 30 years prediction, no existing treatment plants can accommodate the increasing influent rates [3]. This will affect the discharge quality and then affect the current water quality level of Melana River. The main aim of this study is to propose a best project option at Melana River catchment area and reduce the problems of waste water treatment.

2. RESEARCH METHODOLOGY

The study was conducted in terms of three phases. The first phase was to obtain data of connected PE (Population equivalent), design capacity, population growth from the local authorities such as Majlis Perbandaran Johor Bahru Tengah (MPJBT), Indah Water Konsortium (IWK) and Department of Environment (DOE). The second phase was to conduct the in-situ and ex-situ tests, such as wastewater parameters for point source, outfall locations and effluent discharge and the third phase was to apply Qual2E (river water quality modeling software) for analyzing the data. Finally based on the data collected, work was planned to be carried out as four different options for treatment.

2.1 Development of New Sewage Treatment Plant Scheme for Each Sewerage Zone (Small Centralized) - Option I

The option-I was to propose a development of new STP for each sewerage zone, which was designed for organic and nutrient removals by using mechanical-biological treatment. For the specific option Melana catchment was divided into 6 different zones which exist between the upstream and downstream of Melana River. For each zone, a new STP will be proposed for undeveloped area (Sewerage Catchment Zone – as planned by IWK) whereas the existing STP will be maintained as a treatment system for each residential area so that the effluent discharge from the existing STP will not drain directly into Melana River. The effluents will be channeled to the proposed STP at each zone and the new STP will serve as a polishing stage for the

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effluent from all existing STPs before discharged into Melana River.

2.2 Upgrading of the Existing Sewage Treatment Plants for Green Energy Recovery (Centralized) – Option II

The Option-II for the existing oxidation pond was to upgrade new pending system that requires a mechanical biological treatment method to improve the efficiency of the treatment processes. The Anaerobic Baffle Pond (ABP) was used as a replacement for Oxidation Pond (OP) and to be installed together with floating layer on top of it. The ABP is acceptable since the design specification has a similar technical requirement with the existing OP. This could reduce the installation operation and construction costs. Floating cover was suggested to prevent any unpleasant odors from being released to the atmosphere. It is also designed to gather methane gas from the anaerobic digestion processes so that the gas can be used for fuel generator purpose. The energy recovery is important as compulsory for the management of gas residue and sustainable wastewater treatment facility.

2.3 Implementation of Separated Treatment System for Black and Grey Water (Decentralized and Centralized) - Option III

Some of the residential areas, restaurants and commercial premises within Melana catchment typically use the individual septic tank (IST) as their wastewater treatment system. However, some problems have occurred since the existing ISTs are poorly maintained. The dislodging services are only able to reduce the organic pollutant compounds around 50% and unable to remove pathogens or nutrients. This could significantly affect the water quality since effluent from most of the ISTs is currently directly discharged to the river. To reduce the pollutants from existing IST, black and grey water from the wastewater sources must be separated. In order to make this treatment efficient the grey and black water will be treated in separated systems as option III to reduce the concentration of IST influent from black water and the grey water that is being generated from showers, kitchen sink, hand basin, laundry etc and will be post treated using constructed wetland such as subsurface flow wetlands (SSF) before the waste water is discharged.

2.4 Development of New Centralized Sewage Treatment Plant Scheme at Downstream Site of Melana River (Centralized) – Option IV

For Option IV, the new centralized wastewater treatment plant (CWWTP) was proposed in order to replace the decentralized systems that are currently used. It will be developed at the downstream of Melana River, which is located at the open space between Taman Sutera Utama and Taman Perling, Johor Bahru. This section of proposed residential area is acceptable since located at downstream to Melana River and the installation of pump for hydraulic feeding can be excluded which could reduce the cost for installation and maintenance of the pumps. For this option, the discharge from all existing wastewater treatment plants within Melana catchment will be prohibited to discharge directly to Melana River before the centralized treatment system. A sewer pipe was proposed to obtain the effluent from all the existing wastewater treatment plants and transmits it to the new plant. The wastewater treatment plant proposed for Option IV is a combination of Sequencing Batch Reactor (SBR) and Membrane Bioreactor (MBR) which is needed for polishing of the effluent at its final stage to meet the standard set by WQI.

3. RESULTS AND DISCUSSION

The Four options were proposed to improve the performance of sewage treatment system within Melana catchment. This was done in order to ensure the effluent discharge from the STP will strictly follow the standards set by Water Quality Index (WQI) [4]. Each option had different types of the treatment system [5] that was based on the land acquisition, accessibility, treatment quality and the availability of the technology.

The effluent concentration discharged from the treatment plants were taken in the year, 2007. Biological oxygen demand (BOD_5) is considered as an organic pollutant, while total suspended solid (TSS) as the indicator for soil erosion and sedimentation. The calculation for the future effluent was to estimate the concentration of effluent that discharged from the existing treatment plants as a prediction in the next 30 years (2037). Table 1 shows the concentration of BOD_5 and TSS that discharged from the existing treatment plant based on the value of connected PE at 2007 along with the prediction in next 30 years time. Most of the treatment plants still comply with standard of WQI. Based on prediction for future PE within Melana catchment, the estimation of effluent concentration that discharges from existing treatment plants can be calculated [6]. Moreover the prediction of effluent concentration in next 30 years clearly shows that the effluent quality will not comply with the standard of WQI if no improvement is taken to the existing sewage treatment systems.

Table 2 shows the average of effluent concentration that is being discharged from STP in each zone. All though the result shows that the average effluent concentrations discharged from the existing STPs are recorded within the range set by the standards of WQI but if no improvement or upgrading is taken to the existing treatment systems [7], the effluent will increase above the standard limit and will deteriorate the quality of Melana River which is currently

within Class III to IV. Hence it is clear that after improving the STP the effluent discharge can meet the standard limit better than the existing STP.

As per option II for upgrading the existing STP the installation of OP and ABP together will help in improving the water treatment [8] but most importantly will achieve in producing more amount of methane gas because of having floating cover on the top and the prediction of methane production is shown in Table 3. Table 4 shows the comparison of effluent concentration for BOD_5 and suspended solids before and after the upgrading of existing OP. After the completed upgrading process, the concentration of effluent Anaerobic Baffle pond system is able to comply with the standard.

For option-III the modification of the existing septic tank and new plumbing system will be installed to separate the black and grey water [9]. The first compartment will be used as a unit of oil and grease trap, mainly from grey water source. The grey water will then flow to the filter tank before channel out to the proposed constructed wetland. The constructed wetlands have been proposed at undeveloped and open areas, as identified at Tmn Teratai, Tmn Ungku Tun Aminah, Tmn Damai Jaya and Tmn Skudai Baru. The black water will flows to the second compartment in the existing septic tank. The second compartment will act as a storage tank for the sludge as it used for dislodging services. Finally the sludge is disposed to the landfill site (See long, Johor) or transport to solid treatment facility. The concept of using Option III is shown in Fig.1. The Ministry of Housing and Local Government states that the standard wastewater concentration for mix black and grey water is 225 l/cap/day. Grey water from households accounts for 80% of the wastewater quantities and 20% are from black water. Therefore, the flows of wastewater generate from black and grey water for each unit of house is 180 l/d and 45 l/d respectively. After the grey water is treating in constructed wetlands, the expected value for effluent discharged from the wetlands must comply with the standard. To achieve the expected standard, wetlands must be constructed for only certain sizes [10].

In Option IV, a new centralized wastewater treatment plant (CWWTP) is proposed to replace the existing decentralized systems that currently located at downstream of Melana River. For this option, the effluent discharge from all existing STPs within Melana catchment will be connected to a new CWWTP. All effluent will be treated to comply the INWQS. In order to collect the effluent from all the existing STPs and transmits it to the new plant, a network of sewer pipelines is proposed. Table 5 shows the comparison between the design, existing and future prediction for Population Equivalent (PE) and flow capacity of the influent. The data of existing treatment plants such as at Tmn University, Tmn Desa Skudai, Tmn Ungku Tun Aminah and others are already achieved the design limits. After 30 years periods, most of the existing treatment plants will exceed the limits. The population also increases consistently with opening of new residential areas. Even though some of the areas like Tmn Ungku Tun Aminah and Tmn University already congested, the population will still increase by time. Therefore, an improvement of the wastewater treatment system [11] is needed to ensure the capability and efficiency of the treatment plants.

4. CONCLUSIONS

It is seen that Best Project Option (BPO) is sufficient to improve the effluent quality discharged to Melana River. This will ensure the effluent discharge can comply with standard value for the next 30 years. In addition, the improvement STP is mandatory to this area since the existing river water quality falls within Class III to IV which typically unsuitable for urban development. The selections of new treatment plants are based on the suitability and ability of the system to cater the impact in the future.

The required BPO is not only necessary to propose a high technology system but also to be less expensive in capital cost and maintenance. The analysis of the study only focuses in technical aspect such as the justification of proposed treatment system and availability of new location. For future analysis, there are more aspects need to be taken into consideration, such as the cost and benefit of each option, environmental issues and local authority's perspectives.

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REFERENCES

[1] Environmental Quality Act 1974 (Act 127). (1979). Environmental Quality Regulations (sewage and industrial effluent), Department of Environment, Malaysia.

[2] Department of Sewerage Services, Ministry of Housing and Local Government, Malaysia (1998). Guideline for Developers Volume 1. Sewage Treatment Plants.

[3] Eikum, A.S., & Seabloom, R.W. (1982). Alternative Wastewater Treatment. Holland: Kluwer-Academic.

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http://www.ejournalofscience.org

[4] Ahmad, A.Y. (2007). Management of Melana Watershed Using Multicriteria Decision Making Approaches. Postgraduate Thesis. University Teknologi Malaysia, Malaysia.

[5] Babbitt, H.E. & Baumann, E.R. (1958). Sewerage and Sewage Treatment. New York: John Wiley.

[6] Alaerts, G.J., Veenstra, S., Bentvelsen, M. & van Duijl (1990). Feasibility of Anaerobic Sewage Treatment in Sanitation Strategies in Developing Countries. IHE Delft, the Netherlands.

[7] Fair, G.M., Geyer, J.C., & Okun, D.A. (1966). Water and Wastewater Engineering. New York: John Wiley.

[8] U.S. EPA (Environmental Protection Agency). (1983). Process Design Manual for Wastewater Treatment Facilities for Sewered Small Communities. Technology Transfer Series. USA: EPA Publication.

[9] Winneberger, J.H.T. (1976). Manual of Greywater Treatment Practice. USA: Ann Arbor Science Publishing

[10] EPA Guidelines. Managing Vessel Wastewater for Black and Grey Water. 709-07.

[11] Metcalf, A. & Eddy, A. (1995). Wastewater Engineering Treatment and Reuse. 4th Ed. New York: McGraw-Hill.

Table 1: Effluent concentrations from existing STP without any improvement

No	Residential Area	Ref. No	Type of STP	Effluent, 2007 (mg/L)		Effluent, 2037 (mg/L)	
				BOD_5	TSS	BOD_5	TSS
1	Tmn Pulai Jaya	JKI 066	EA	10	14	145	208
2	Tmn Teratai	JBT 056	OPPS	22	68	170	233
3	Tmn Sri Pulai	JBT 001	OP	18	40	157	220
4	Tmn Sri Pulai Perdana	JBT 196	SBR	14	25	150	213
5	Tmn Sri Pulai Flora	JBT 241	EA	15	21.5	149	211
6	Tmn University	JBT 002	OPPS	3	3	140	203
		JBT 003	OP	50	60	167	229
		JBT 004	OP	57	80	176	238
		JBT 005	OP	56	80	176	238
7	Tmn Pulai Utama	JBT 246	EA	10	20	148	211
8	Tmn Desa Skudai	JBT 018	OP	20	38	156	219
		JBT 159	EA	8	18	147	210
9	Tmn Skudai Baru	JBT 010	OP	31.5	76	174	225
		JBT 011	OP	16	50	162	237
10	Tmn Ungku Tun Aminah	JBT 012	ITPS	60	24	150	212
		JBT 015	IT	46	31	153	216
		JBT 016	ITPS	61	31	153	216
		JBT 037	IT	30	8	143	205
		JBT 039	IT	56	33	154	217
		JBT 040	IT	49	34	155	217
		JBT 041	ITPS	49	21	149	211
		JBT 042	ITPS	7	24	150	212
		JBT 043	ITPS	42	24	150	212
		JBT 044	ITPS	26	19	148	210
		JBT 045	IT	68	30	153	215
		JBT 046	ITPS	5	8	143	205
		JBT 048	ITPS	3	8	143	205
		JBT 049	ITPS	30	20	148	211
		JBT 050	IT	58	50	162	224

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		JBT 051	ITPS	23	19	148	210
		JBT 052	ITPS	36	21	149	211
		JBT 053	ITPS	37	23	150	212
		JBT 054	IT	40	30	153	215
		JBT 055	IT	51	31	153	216
11	Tmn Mutiara Rini	JBT 203	EA	13	21	139	201
12	Tmn Sri Orkid	JBT 148	SBR	28	98.5	149	211
13	Tmn Damai Jaya	JBT 017	OP	9	34	184	247
14	Tmn Timor	JBT 124	OP	30	50	155	217
15	Tmn Timur (Fasa II)	JBT 127	AB	8	6	162	225
16	Tmn Jaya Mas	JBT 155	SBR	2	13	142	204
17	Tmn Tan Sri Yaakob	JBT 135	ODPS	44	13	145	207
18	Bandar Uda Utama	JBT 220	EA	2	6	145	207

* OP: Oxidation Pond, OPPS: Oxidation Pond with Pump Station, SBR: Sequencing Batch Reactor, IT: Imhoff Tank, ITPS: Imhoff Tank with Pump Station, OD: Oxidation Ditch, AB: Acty Bio, EA: Extended Aeration

Table 2: Effluent analysis from STP for Option 1

Zone	Average Effluent from Existing STP (2007)		Average Effluent from Existing STP (2037)		Effluent from Proposed STP (2037)	
	BOD_5	**TSS**	**BOD_5**	**TSS**	**BOD_5**	**TSS**
1	16	34	154	217	10	13
2	20	32	154	216	10	14
3	53	70	171	234	11	15
4	39	27	151	213	10	13
5	13	40	157	219	10	14
6	23	10	143	206	9	13

*unit in mg/L

Table 3: Estimation of methane gas production and floating cover in anaerobic baffle pond system (2037)

Location	Ref. No.	PE (2037)	Q (m^3/d)	Additional Pond	Methane Production (m^3/d)	Floating Cover (m^2)
Tmn Teratai	JBT 056	9212	2073	2	390	8491
Tmn Sri Pulai	JBT 001	25119	5652	2	1063	23152
Tmn University	JBT 002	20594	4634	2	872	18981
	JBT 004	33758	7596	2	1429	31114
	JBT 003	48000	10800	2	2032	44241
	JBT 005	40097	9022	2	1697	36957
Tmn Damai Jaya	JBT 017	3240	729	2	137	2986
Tmn Timor	JBT 124	3521	792	2	149	3245
Tmn Skudai Baru	JBT 010	12041	2709	2	510	11098
	JBT 011	39525	8893	2	1673	36430

Table 4: Comparison of effluent from Oxidation Pond and Anaerobic Baffle Pond systems for option-II

Residential Area	ID	BOD_5 (mg/L)*	TSS (mg/L)*

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		OP (2007)	ABP (2037)	OP (2007)	ABP (2037)
Tmn Teratai	JBT 056	22	16	68	19
Tmn Sri Pulai	JBT 001	18	16	40	19
Tmn University	JBT 002	3	16	3	19
	JBT 003	50	16	60	19
	JBT 004	57	16	80	19
	JBT 005	56	16	80	19
Tmn Skudai Baru	JBT 010	32	16	76	19
	JBT 011	16	16	50	19
Tmn Damai Jaya	JBT 017	9	16	34	19
Tmn Timur	JBT 124	30	16	50	19

***Note:** The estimated BOD_5 and TSS are based on 14 days of hydraulic retention time and 95% removal

Table 5: Existing STPs that connected to main sewer pipelines for new centralized wastewater treatment

Location	Ref. No.	Design		Existing (2007)		Future (2037)	
		PE	Q (m^3/d)	PE	Q (m^3/d)	PE	Q (m^3/d)
Tmn Pulai Jaya	JKI 066	31700	7133	9275	2087	20032	4507
Tmn Teratai	JBT 056	8270	1861	4265	960	9212	2073
Tmn Sri Pulai	JBT 001	11630	2617	11630	2617	25119	5652
Tmn Sri Pulai Perdana	JBT 196	13500	3038	13070	2941	28229	6352
Tmn Sri Pulai Flora	JBT 241	6000	1350	1430	322	3089	695
Tmn University	JBT 002	11000	2475	9535	2145	20594	4634
	JBT 003	22159	4986	22224	5000	48000	10800
	JBT 004	15345	3453	15630	3517	33758	7596
	JBT 005	18565	4177	18565	4177	40097	9022
Tmn Pulai Utama	JBT 246	26040	5859	19166	4312	41395	9314
Tmn Desa Skudai	JBT 018	2600	585	2600	585	5616	1264
	JBT 159	4500	1013	2580	581	5572	1254
Tmn Ungku Tun Aminah	JBT (016, 041, 042, 043, 045, 046, 048, 049, 050)	10540	2372	9840	2214	21253	4782
	JBT (051, 052, 053, 054, 055)	6880	1548	6880	1548	14860	3343
	JBT (012, 015, 037, 039, 040, 044)	3520	792	3360	756	7257	1633
Tmn Skudai Baru	JBT 010	5815	1308	5575	1254	12041	2709
Tmn Sutera Utama	JBT 214	15000	3375	4355	980	9406	2116
Tmn Mutiara Rini	JBT 203	35000	7875	11205	2521	24201	5445
Tmn Sri Orkid	JBT 148	12500	2813	6990	1573	15097	3397
Tmn Damai Jaya	JBT 017	1500	338	1500	338	3240	729
Tmn Timor	JBT (124, 127)	2245	565	2115	476	4568	1028
Tmn Jaya Mas	JBT 155	5800	1305	3900	878	8423	1895
Tmn Skudai Baru	JBT 011	23180	5216	18300	4118	39525	8893
Tmn Tan Sri Yaakob	JBT 135	25710	5785	14820	3335	32009	7202
Bandar Uda Utama	JBT 220	14700	3308	18040	4059	38963	8767

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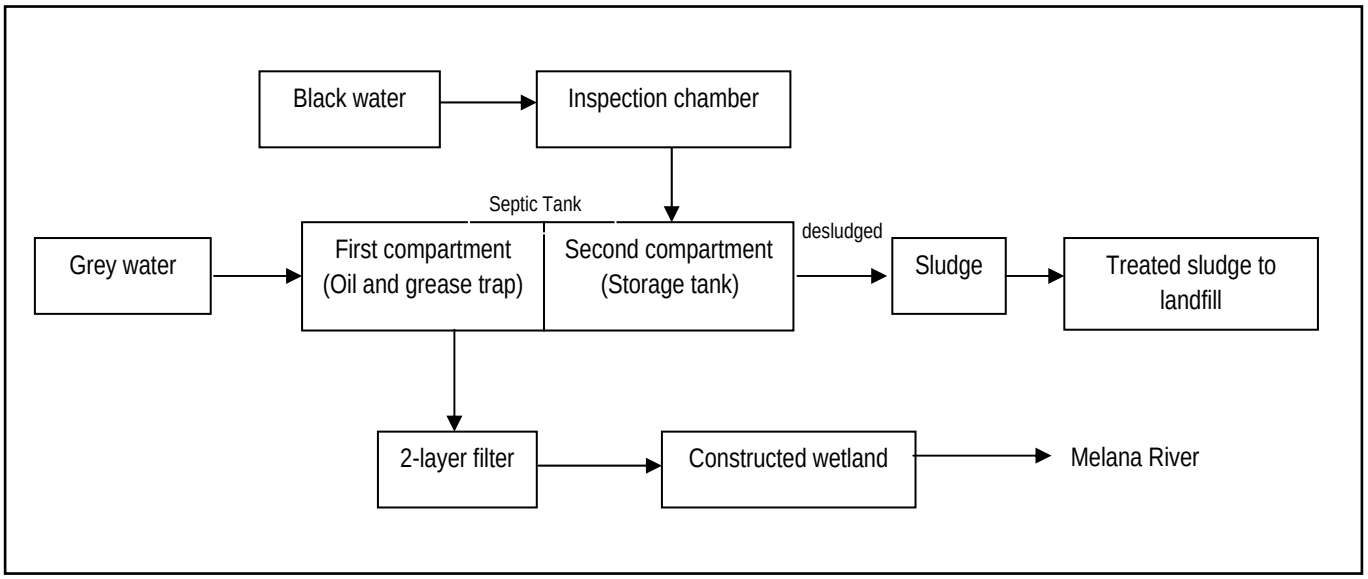

Fig 1: The IST Treatment Process (Separated System)