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FACTORS INFLUENCING WATER TREATMENT MANAGEMENT PERFORMANCE IN MALAYSIA: A CASE STUDY IN PULAU PINANG

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ABSTRACT: Growing water scarcity threatens economic development, sustainable human livelihoods, environmental quality, and a host of other societal goals in countries and regions around the world. Urban population growth, particularly in developing countries, places immense pressure on water and land resources; it also results in the release of growing volumes of wastewater – most of it untreated. The aim of this study is investigate the factors that influencing water treatment performance of water treatment plant that located at Batu Ferringhi, one of the water treatment plant in Penang State. Interview has been carried out and some conclusion has been drawn and provided.
KEYWORDS: Factors, Water treatment, Performance, Pinang Island, Malaysia

❖ INTRODUCTION

Drinking water can come from both surface water and ground water. The water cycle begins with rainwater falls in lakes and rivers which interact with ground water. Because of huge volume and flow conditions, the quality of natural water cannot be modified within the body of water. Follow a drop of water from the source through the treatment process. Water may be treated differently in different communities depending on the quality of the water which enters the plant. Groundwater is located underground and typically requires less treatment than water from lakes, rivers, and streams.

The treatment plant is designed to allowing operators, technicians or staff operating and maintaining water treatment system, emphasizing safe practices and procedures. They have knowledge to control and reduce odors in drinking water, perform basic water laboratory procedures, and solve arithmetic problems commonly associated with water treatment plant operations. An importance of the course provides operators information on overall plant operation and covers topics such as daily operating procedures, regulation of flows, chemical dosing and handling, records and reports, plant maintenance, safety and security, emergency conditions and procedures, handling complaints, and energy conservation. The water treatment process at the Batu Ferringhi treatment plant, and all other PBAPP plants, is similar to the majority of worldwide water treatment facilities. It complies with the world health organization (WHO) guidelines and the ministry of health (MOH) parameters.

The Batu Ferringhi treatment plant is located on a hillside site overlooking the sea. Opened in 2001 this treatment plant is a key component of the Teluk Bahang water supply project that was started in the 1990s to help resolve the issue of limited water resources in Penang. This treatment plant is equipped to treat a maximum of 120 million liters of water a day (MLD) from the Teluk Bahang Dam, Penang's strategic reserve dam for the annual dry season. When the dam's water level is high, raw water is drawn to the treatment plant through a 3.4 KM transfer tunnel by gravity. If the water level drops beneath the requirement for gravity transfer a high-lift pumping station will pump water from the dam to the transfer tunnel and then flow by gravity the plant.

The Batu Ferringhi treatment plant is equipped with modern treatment facilities as well as the SCADA system, which can facilities plant operations such as backwashing of filters, chemical dosing pumpset operation and logging / display of treatment process parameter. PBAPP uses an "online" supervisory control and data acquisition system (SCADA) which speeds up remote operation, SCADA also helps:

- Real-time monitoring
- Treatment plant performance
- Water quality and distribution processes
- Trending of measure parameters (real-time and historical data)
- Archiving historical data ;
- Generating daily and monthly reports

❖ FACTORS INFLUENCING WTMP

Factors influencing water treatment plant performance (WTMP) can be listed down as below:
a) User opinions and satisfaction
b) Community management
c) Level of service
d) Financial status
e) Materials and equipment
f) Personnel
g) Work order control

a) User opinions and satisfaction

The user opinions and satisfaction can influence the water treatment plant performance indirectly. This is because the user is always aware with the quality of the water use in the house, office and etc. The quality of water such as color, odor can give negative reaction to the user. Normally user will find out is there any piping problem in their area. If that occur, then it will be a normal condition for temporary. But if the situation continuously happen, there must be something wrong and the user will report or complaint on their satisfaction towards PBA (Perbadanan Bekalan Air Penang). PBA will try to solve the problem and find out the solution. This is to avoid a bad reputation and images towards PBA if the complaint continuous. PBA might have made an experiment to ensure the quality of the water, track record of all operation and maintenance done. The machine operation and function will be examines. Thus, indirectly the complaints from the user have influence the performance of the water treatment plant.

b) Community Management

The community management is responsible to ensure that the water treatment plant is well manage such as under control and well operate hence produce quality water. The water treatment plants need to be monitor because it is generated by a machine and automatic run. The operator is needed to monitor and supervised the machine operations. The management will organize the responsible staff on duty. A schedule of maintenance is prepared to supervise the performance of water treatment plant. The operator must be full time working for controlling and operating the water treatment machine.

c) Level of service

Water quality is defined in terms of the chemical, physical, and biological content of water. The water quality of rivers and lakes changes with the seasons and geographic areas, even when there is no pollution present. There is no single measure that constitutes good water quality. For instance, water suitable for drinking can be used for irrigation, but water used for irrigation may not meet drinking water guidelines. Water quality guidelines provide basic scientific information about water quality parameters and ecologically relevant toxicological threshold values to protect specific water uses. Many factors affect water quality. Substances present in the air affect rainfall. Dust, volcanic gases, and natural gases in the air, such as carbon dioxide, oxygen, and nitrogen, are all dissolved or entrapped in rain. When other substances such as sulphur dioxide, toxic chemicals, or lead are in the air, they are also collected in the rain as it falls to the ground. Rain reaches the earth's surface and, as runoff, flows over and through the soil and rocks, dissolving and picking up other substances. For instance, if the soils contain high amounts of soluble substances, such as limestone, the runoff will have high concentrations of calcium carbonate. Where the water flows over rocks high in metals, such as ore bodies, it will dissolve those metals. Water Treatment plant supply a water quality through the multi level of process. This involves reservoir, disinfection, coagulation, flocculation, sedimentation and filtration. The reservoir can hold up to nine billion gallons of water. The disinfection process is to add up chlorine dioxide to kill bacteria and microorganisms in the water. The coagulation process is Ferric chloride and cationic polymer are quickly added and mixed into the water to begin the process of removing dirt and particles. Flocculation process is gentle mixing of the ferric chloride and polymer in the water causes dirt particles to stick together and become heavy, forming rust-colored "floc" clumps. The heavy, sticky floc clumps settle to the bottom of the basins, where they are vacuumed up by the traveling bridge. The remaining water flows over an end baffle, and then moves to the filters through sedimentation process. The water passes down through filters (layers of anthracite coal, sand

and gravel) which trap and remove the remaining particles. Chlorine and ammonia are added for disinfection in the distribution system at the filtration process.

d) Financial Status

The water treatment involves a lot of expenditure on the machinery, the building, the workers, dams and chemical treatment. This process involve big sum of money to make it operate. Because of this reason, the government has allocated a lot of money to enable the water treatment well function. Thus, the user will get the benefit from this investment and can use the water safely. The expenditure spend is too ensure that the water treatment plant can perform well and produce quality water. The management involve also will give the best service to user in order to get a better quality of water.

e) Materials and equipment

The machinery and equipment use is suitable for processing the water, so that it can be use as drinking, farming, and industry. The machinery can be use for a long term use and using a new technology to give a better performance towards water production.

f) Personnel

One of the factors influencing water treatment management performance is the technician and/or staff availability and training. Clean water is essential for good health, recreation, fish and wildlife, and industry. *Water treatment plant operators* treat water so that it is safe to drink. A competent operator will have much influence to the performance of the water treatment system. Operators need mechanical aptitude and should be competent in basic mathematics, chemistry, and biology. They must have the ability to apply data to formulas of treatment requirements, flow levels, and concentration levels. Some basic familiarity with computers also is necessary because of the trend toward computer-controlled equipment and more sophisticated instrumentation. Operators control processes and equipment to remove or destroy harmful materials, chemical compounds, and microorganisms from the water. They also control pumps, valves, and other processing equipment to move the water or wastewater through the various treatments processes, and disposes of the removed waste materials. Operators read, interpret, and adjust meters and gauges to make sure plant equipment and processes are working properly. They operate chemical-feeding devices, take samples of the water or wastewater, perform chemical and biological laboratory analyses, and adjust the amount of chemicals, such as chlorine, in the water. They use a variety of instruments to sample and measure water quality, and common hand and power tools to make repairs. Operators also make minor repairs to valves, pumps, and other equipment. Occasionally operators must work under emergency conditions. A heavy rainstorm, for example, may cause large amounts of wastewater to flow into sewers, exceeding a plant's treatment capacity. Emergencies also can be caused by conditions inside a plant, such as chlorine gas leaks or oxygen deficiencies. To handle these conditions, operators are trained in emergency management response using special safety equipment and procedures to protect public health and the facility. During these periods, operators may work under extreme pressure to correct problems as quickly as possible. These periods may create dangerous working conditions and operators must be extremely cautious. The specific duties of plant operators depend on the type and size of plant. In smaller plants, one operator may control all machinery, perform tests, keep records, handle complaints, and do repairs and maintenance. A few operators may handle both a water treatment and a wastewater treatment plant. In larger plants with many employees, operators may be more specialized and only monitor one process. The staff may also include chemists, engineers, laboratory technicians, mechanics, helpers, supervisors, and a superintendent. Water and wastewater treatment plant operators increasingly rely on computers to help monitor equipment, store sampling results, make process control decisions, schedule and record maintenance activities, and produce reports. When problems occur, operators may use their computers to determine the cause of the malfunction and its solution.

g) Working conditions

Next factor is the working conditions. Water and wastewater treatment plant operators work both indoors and outdoors and may be exposed to noise from machinery and unpleasant odors. Operators have to stoop, reach, and climb and sometimes get their clothes dirty. They must pay close attention to safety procedures for they may be confronted with hazardous conditions, such as slippery walkways, dangerous gases, and malfunctioning equipment. Plants operate 24 hours a day, 7 days a week; therefore, operators work one of three 8-hour shifts and weekends and holidays on a rotational basis. Whenever emergencies arise, operators may be required to work overtime. Hence, working conditions will influence the water treatment performance.

h) Monitoring and control of water treatment

Monitoring and control of water treatment is also a factor that influences the performance of the water treatment system. Most industrial water treatment systems are dynamic. They constantly undergo changes because of seasonal variations in water chemistry, varying plant operating conditions, new environmental laws, and other factors. Because of this, proper monitoring is essential to ensure that the water treatment program applied to a boiler, cooling, wastewater or other industrial water

system is satisfactorily controlled so that the desired results are achieved. Some of the value added benefits obtained through proper monitoring of a water treatment program include:

- Reduced risks associated, with chemical underfeed or overfeed;
- Continuing compliance with environmental regulations;
- Improved quality of plant operation;
- Increased water and energy savings; and
- Improved plant productivity

Industrial water treatment systems may be monitored by manual methods or by continuous systems employing automatic instrumentation (Adapted from Water and Wastewater Treatment Plant Operators and Monitoring and control of water treatment). Wilderer (2001) described the conceptualization of the onsite water differentiable treatment system in two category, centralized water management systems and decentralized water management systems. In centralized water management systems, he mentioned that despite of positive aspects of the centralized water-wastewater management systems (reliable and efficient management and control); these have disadvantages which should not be neglected, especially in view of the integrated product policy (IPP) concept adopted by the EU (Wilderer, 2001). The cost benefits of central systems diminish when the costs of building and maintaining the distribution and collection system are taken into account. Surveys conducted in many cities have revealed extensive leakage causing infiltration of groundwater and exfiltration of wastewater and subsequent groundwater pollution. Estimating the cost of worldwide implementation of centralized systems, it becomes evident that the capacity of the global money market would not be sufficient to cover the need for investment capital. It is hard to believe that centralized systems are seen as the best solution for problems in developing countries, especially in mega-cities. On the other hand, the treatment results achieved in practice by the decentralized water-wastewater management systems are not satisfactory when the IPP-relevant criteria (low consumption of resources, long-lasting technology, and advance treatment requirements) are used as a measure (Wilderer, 2001). There are three major concerns:

a) The effluent quality is mostly low and rarely allows safe reuse of water.
b) Treatment plants are not properly operated.
c) Plants are difficult to supervise and control by water authorities.

A study on factors influencing water management performance is carried out by (Sujaritpong and Nitivattananon, 2009) determined the critical factors influencing water management performance at housing estates in suburban Bangkok in Thailand by using multiple regression analysis. There are three significant factors encompassing financial, social, institutional and general aspects were identified for community centralized and onsite water management system. For the community centralized system, the key factors were house price, type of organization managing the housing estate, and the attitudes of the organization. For onsite systems, three factors identified were total number of house units, direct experience with water pollution and percentage of occupied houses. From the multiple regression analysis, the correlation between a set of factors and overall water management performance results, as measured by the coefficient of determination (R^2), was found to be rather high for housing estates with community centralized water management, but only medium for housing estates with an onsite system. In this study, half of the performance aspects assessed in this study were classified as poor due to several institutional factors that act as barriers to improvement in community water management, including inadequate monitoring and enforcement, fragmentation and poor communication among authorities, inadequate capacity of responsible agencies, lack of interest in water management from LGAs and Housing Estate management. A research on sustainable urban wastewater management is carried by researchers in Turkey (Alaton *et al.,* 2010). Data was collected from the government agencies and by directly contacting the personal in charge of the existing urban water treatment plants of the country. They mentioned that water and wastewater management have to be considered in conjunction with each other. Additionally, they found that there are certain factors that influence the performance of water treatment plant as following:

a) Monitoring and control system of existing water treatment plant
b) Socio-cultural and economical factors regarding water supply and wastewater reuse
c) Coordination between the national and local authorities
d) Efficient and sufficient systematic database for the sewer collection and treatment
e) Type of treatment and discharge environment of the effluent.

In relation to the performance of water treatment plant in Turkey, relatively new treatment plants are capable of removing 96-99% Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD_5) and Total Suspended Solids (TSS) from the water. For older treatment plant, the treatment efficiency ranges between 0-90percent. The treatment performance is fluctuating and not always satisfactory enough to comply with the national discharge consents. The unit price of electrical energy was 0.13 YTL/kWh corresponding to 0.074 EUR/kWh (Alaton *et al.*, 2010). In the evaluation of the present onsite water treatment systems in Palestinian rural areas in Ramallah-Albireh district, a

specialized questionnaire was developed and distributed to 200 households in four randomly selected villages with less than 5,000 persons and having onsite water treatment facilities. WAWTTAR software package was used to evaluate 16 different treatment systems based on technical, environmental, financial and socio-cultural considerations (Al-Sa'ed & Mubarak, 2006). In this study, technology and environmental impacts and appropriateness, in the context of the availability of skilled personnel to operate and maintain it, as well as socio-cultural factors were taken into account as following:

a) Environmental – planning, traffic and access, visual, housing proximity, ecology, archaeology, recreation/amenity, construction impacts and third party issues.
b) Institutional factor.
c) Social – build ability, operability and process robustness.
d) Economical – capital expenditure, operating expenditure and whole life costs.

According to Huu and Facon (2001), the factor which affects the allocation of water among users and the efforts of the people to achieve a better living are briefly discussed below.

a) Institutional and legal issues - Conflicts in water resources management such as allocation of water rights, flood management, pollution control, environmental protection, etc, are resolved through inter agency coordination and consultation. However at the federal level, a National Water Resources Council (NWRC) has been set up to pursue a more effective water management, including the implementation of interstate water transfers.
b) Competition for water - The exponential growth in urban population has stretched the government's ability to answer infrastructure and service needs and provide the environmental conditions required for better living. Often the supporting infrastructure for the collection, treatment and disposal of sewage and solid wastes is inadequate to cope with the amounts generated. This state of affairs raises problems of water and air pollution, public health and urban environmental degradation. The increased demand for the limited and diminishing supply of clean water available has led to competition among the various water users, a competition the continued economic growth exacerbates increasingly.
c) Development of public utilities - The development of public utilities such as water supply, sewerage and urban drainage and flood mitigation programs helps to promote economic growth and improve the quality of life. Almost all of the investments in water related infrastructure depend on reasonable river water quality.
d) Efficiency of water use - Efficiency of water use in general is low. Irrigation efficiency is in the range of 40% to 50% because almost all of the irrigation systems are open systems designed to take advantage of flooding. As the physical limits of water supply are being reached, more emphasis is now placed on reducing the losses and thus increasing the net supply trough improved efficiency in water use.
e) Expectation of the people - The increased expectations of the people will bring about heavier demands on the water resources both for water supply and for pollution control. In the context of increased demand from population growth and industrialization competing for diminishing water availability, the need for optimum utilization of water takes on greater urgency, moving towards efficiency and effectiveness of use, as well as conservation and sustainability.

Balkema *et al.,* (2002) proposed a general assessment methodology that builds on multi-objective optimization and a complete set of sustainability indicators which yielding insight into the trade-offs made when selecting sustainable water treatment systems. The sustainability indicators are as below:

a) Functional Indicators - Functional indicators define the minimal technical requirements of the solution. For instance, water treatment this may be the minimal required effluent quality. Additional indicators may be adaptability (possibility to extend the system in capacity, or with additional treatment), durability (lifetime), robustness (ability to cope with fluctuations in the influent), maintenance required, and reliability (sensitivity of the system to malfunctioning of equipment and instrumentation).
b) Economic Indicators- costs of investment, operation, and maintenance. Derived indicators are for instance affordability, cost effectiveness, and labor.
c) Environmental Indicators – accumulation, biodiversity, dissication, extraction, integration in natural cycles, nutrients, energy, emissions BOD/COD and sludge/waste production.
d) Technical Indicators – durability, ease of construction, endure shock loads, flexibility, reliability and small scale solution.

Social-Cultural Indicators – awareness, competence, cultural acceptance, institutional requirements, local development and responsibility.

❖ METHODOLOGY

The aim of this study is to study the factors that influencing water treatment performance of water treatment plant that located at Batu Ferringhi, one of the water treatment plant in Penang State. An interview (primary data) is used to clarify the data obtained. This step is important for the

researcher to have better understanding about water treatment that practiced in Batu Ferringhi water treatment plant. In order to get the relevant information, the researcher had a session of interview with Mr. Zulkiflee (Superintendent of Batu Ferringhi treatment plant) and obtained important information about all process regarding the plant located at Batu Ferringhi. The technician introduced every stage of water treatment and all the facilities that existing in the plant. Other data (secondary data) have been obtained from many sources such as official website of PBA (Perbadanan Bekalan Air), previous published articles and books as well as some brochures that given by Mr. Zulkiflee.

❖ DESCRIPTION OF THE WATER TREATMENT PLANT AT BATU FERRINGHI IN PINANG ISLAND

The water treatment process at the Batu Ferringhi Treatment Plant (Figure 1), and all other PBAPP plants, is similar to the majority of water treatment facilities worldwide. It complies with the World Health Organisation (WHO) guidelines and the Ministry of Health (MOH) parameters.

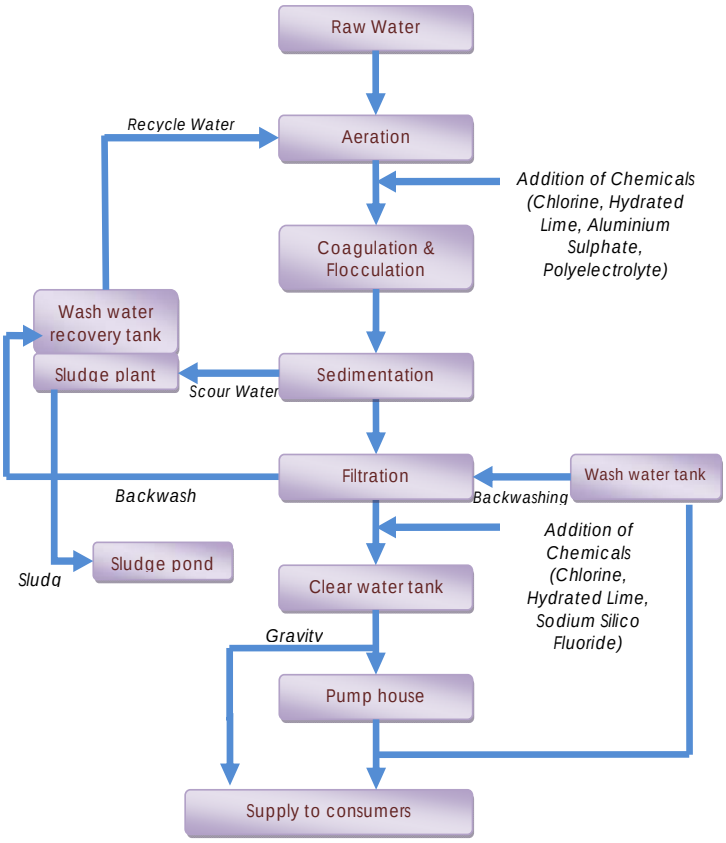

Figure 1: Water Treatment Process

Raw water is drawn from the Teluk Bahang Dam to the treatment plant via a 3.4km transfer tunnel by gravity. The Teluk Bahang Dam is chosen as its source of water due to its less polluted and less contaminated catchment area. Before entering the main water treatment processes, the raw water will undergoing preliminary treatment. Screening is usually the first step in the water pretreatment process. It removes large debris like leaves, sticks and fish that can foul or damage the plant equipment. After that, the water will enter the process of **aeration**. Aeration is the process of bubbling air through a solution, sometime cleaning water of impurities by exposure to air. Aeration is used to treat water that contains trapped gases (such as hydrogen sulfide) that can impart an unpleasant taste and odour to the water. Aeration works well when the pH of the water is less than 6.5. Following screening, aeration and other pretreatment process, the next process in this water treatment system is a mixer where chemicals are added in what is known as **coagulation and flocculation**. Coagulation is designed to convert stable (unsticky) particles to unstable (sticky) particles. Coagulation refers to the series of chemical and mechanical operations by which coagulants are applied and made effective.

These operations are comprised of two distinct phases: (1) rapid mixing to disperse coagulant chemicals by violent agitation into the water being treated. (2) Flocculation to agglomerate small particles into well-defined flock by gentle agitation for a much longer time. There are four chemicals used, namely **chlorine, hydrated lime, aluminium sulphate and polyelectrolyte**. **Chlorine** is used as disinfectant in breakpoint chlorination. As the conventional water treatment plant, at this stage, chlorine is typically added for pre-chlorination at either the raw water intake or flash mixer and for intermediate chlorination ahead of the filters. Breakpoint chlorination is the point at which near complete oxidation of nitrogen compound is reached, any residual beyond breakpoint is mostly free chlorine. To produce breakpoint chlorination, enough chlorine must be added to the water. At this stage, **aluminum sulphate** is used as a coagulant aid while **polyelectrolyte** is used as a flocculant aid. **Hydarated lime** is used for pH adjustment to the water. After raw water and chemicals have been mixed and the flock formed, the water containing the floc flows to the **sedimentation**. Sedimentation removes settleable solids by gravity. Water moves slowly through the sedimentation basin. Scour water is produced and transferred to the sludge plant. Sludge accumulates at the bottom of the sludge basin. The accumulated sludge is discharged to the sludge pond. There are certain conditions that affect the sedimentation:

1) Uniformity of flow of water through the basin.

2) Stratification of water due to difference in temperature between water entering and water already in the basin.
3) Release of gases that may collect in small bubbles on suspended solids, causing them to rise and float as scum rather than settle as sludge.
4) Disintegration of previously formed flock
5) Size and density of the flock

The Next process is the **filtration**; water filtration is a physical process of separating suspended and colloidal particles from water by passing water through a granular material. The process filtration involves straining, settling and adsorption. As flock passes into the filter, the spaces between the filter grains become clogged, reducing this opening and increasing removal. Some material is removed because it settles on a media grain. Adsorption of the flock onto the surface of individual filter grains helps collect the flock and reduces the size of the openings between the filter media grains. Filtration also contributes to the removal of bacteria and protozoans and also used for iron and manganese removal. After the filtration, the chemicals are added and mixed with the filtered water in the **clear water tank**. Chemicals added are chlorine, hydrated lime and sodium silico fluoride. At this stage, chlorine is added for postchlorination at the filter clearwell and also rechlorination of the distribution system. Once again, hydrated lime is added to balance the pH of the filtered water. Sodium silico fluoride is added as a protection for teeth. Water is stored at a waterworks operation (**pump house**) to provide allowance for difference in water production rates and high lift pump discharge to the distribution system. Clean and safe water produced within the distribution system is stored in underground pipe and ready to **supply to consumers** by gravity. Water not being supplied to consumers will transferred back to **wash water tank**. This process is called backwashing. It fluidizing filter media with water, air or a combination of the two so that individual grains can be cleaned of the material that has accumulated during the filter run. Backwash water produced from the filtration will transferred to the **wash water recovery tank.** The water is recycled and enters into the aeration process and the rest of the treatment process until it is safe and clean to supply to consumers.

❖ RESULTS AND DISCUSSION

After conducted the site visit and interview with superintendent of water treatment plant (Mr. Zulkiflee) which is located at Batu Ferringhi in Penang Island, the results obtained from the interviewer can be categorized into several factors that can influence the water treatment performance and quality. For instances, operation factor, maintenance factor, human resources management factor (shift, awareness and training), financial status factor, work order control factor, level of services factor, and users / consumer satisfaction factor.

Operation

Water treatment operations are carried out to provide reliable and high quality water service for customers / users**,** and to protect the environment for future generations. The current condition in operating the water treatment at treatment plant Batu Ferringhi according to the answer of Mr. Zulkiflee, the water treatment plant was running or operating in minimum production. This is because the water treatment plant is conventional plant which is operating in minimum production. The treatment plant management is complied the ISO standard which is base on ISO 9001:2000 - Quality Management, ISO 14001:2004 - Environmental Management and OHSAS 18001:1999 - Occupational Safety & Health Management. The ISO 9001:2000 - Quality Management as a guide for the water treatment and supply of water and provision of customer services which is issued by DAR (Germany) and UKAS (UK). The standard of ISO 14001:2004 Environmental Management is for the management and treatment of raw water and supply of potable water at Batu Ferringhi Treatment Plant and Teluk Bahang Dam, eight other treatment plants at Penang are working towards similar certifications and two major dams. This standard is also issued by UKAS (UK). The OHSAS 18001:1999 - Occupational Safety & Health Management is for the treatment and supply of water and provision of customer services. And it is issued by issued by SGS International, with accreditation to Swiss Certification. There are stages of water treatment treat source water which need several materials and equipment to operate. The quality and function of machinery being used to run the water treatments are complete machine function. The Batu Ferringhi Treatment Plant was constructed complied the BS Standard's requirements (British Standard). They are request the engineers / consultants to meet the standards comply with the BS standards. Therefore, the plant or equipment that use on site or plant are complying standards or minimum requirements and are in good conditions. And the materials that use to carry out the water treatment task were achieved the standards or requirements. The quality of machinery, equipment and water are achieved the minimum requirements from PBA (Perbadanan Bekalan Air)

The Batu Ferringhi treatment plant is equipped with modern treatment facilities like SCADA system, which can facilitate plant operations such as backwashing of filters, chemical dosing, pumpset operations and logging / display of treatment process parameters. The Supervisory Control and Data

Acquisition System (SCADA) is an "online" supervisory system that be used by PBAPP, which will helps to speeds up remote operation. SCADA helps in:

- Real-time monitoring of treatment plant performance;
- water quality and distribution processes;
- Trending of measure parameters (real-time and historical data);
- Archiving historical data; and
- Generating daily and monthly reports

Maintenance

Most of the possessions we owned may require a certain amount of routine maintenance or service. Whether it is daily inspection and adjustment, monthly and yearly inspection, an equipment, machinery or materials are requires some maintenance to provide reliable service and to provide operational continuously throughout its normal operational life. The machinery and equipment of plant are been checking and maintain in monthly basis. The overhead and compressor's maintenance, checking and monitoring works is conducted on yearly basis. According to Mr. Zulkiflee, the current condition in maintaining the water treatment system of Batu Ferringhi water treatment plant was satisfying. The catchment areas have been maintaining to get the better quality before any process of water treatment. The raw water from the Teluk Bahang Dam which is near the Batu Ferringhi is available at the treatment plant to be disposal and process. After the raw water have been disposal, processed, and been treated, the water then can be used by users from local area / residential area (households) or industrial area. The schedule waste will form after the process, thus the schedule waste will be send to local government dumping area such as Jelutong and Pulau Burung. And the report will be send to environment department. The personnel such as staff, general workers and technician are practicing the maintenance of the system correctly. The overall knowledge of operation and maintenance are satisfying. The personnel are having adequate knowledge of types of water treatment system, knowledge of system maintenance the impacts from incorrect maintenance. All staffs / technicians are been trained and given the adequate knowledge in operation and maintenance. Although general workers understanding and have relevant knowledge, but only the technician and operator will carry out the operation or maintenance's works.

It can categorize maintenance as either reactive or preventive. Reactive maintenance occurs when equipment fails unexpectedly. Preventive maintenance occurs according to an organize method to address potential problems. The proper and constant maintenance are needed to ensure the operation of plant, machinery and equipment running normally and safely for use. According to Mr. Zulkiflee that are cases of hazards occur due to lack of proper maintenance for example, chlorine gas leakage will lead to serious fatal, that is happened in India, Russia and occur at Ipoh, Perak before. The constant and proper maintenance ensure to reduce the risk of hazard. The chlorine gas leakage problems never occur at the water treatment Batu Ferringhi according to Mr. Zulkiflee. The impacts of this hazard will seriously affect the surrounding live or human being. When maintaining the machinery, the cleaning process will produce sludge. The sludge will be reprocessing again to make sure that is no sludge flow or discharge to the river. Therefore, this will protect the environment by not to polluted the river or environment. And the quality of water pipe are been maintained periodically. The maintenance works are carrying out on daily, monthly or yearly basis. But in case of occurs emergency or equipments are failed to function, maintenance or service works will be conducted immediately. For example the deterioration process are need to carry on operation, if found that is abnormal or cannot function normally would request for maintenance immediately.

Human Resources Management (Shift, Awareness and Training)

To allow or to properly operate a water treatment system usually requires a team of skilled personnel filling the several of job classifications. The positions such as plant superintendent, operators, maintenance operator, technicians, laboratory professionals and administrator are involve to operate, monitoring and manage the water treatment system and water treatment plant. The duties of plant operators or technicians depend on the type and size of plant. The Batu Ferringhi water treatment plant is small conventional plant. Therefore, in small plant that is two to three operators may control / monitoring all machinery, carry out lab test or lab analyses, keep records, handle customer's complaints, troubleshoot and make repairs and responsibility to carry out the constant maintenance. The working hours of the superintendent, operators and technicians are worked morning shifts, noon shifts and / or night shifts. The working conditions of water treatment plant operators or technicians work indoors and outdoors in all kinds of weather. Operators or technicians at Batu Ferringhi treatment plant generally work in shift. The treatment plant is in operation 24 hours per week, thus operators and technicians or other personnel that involve in operation have to work morning, noon and night shift. Some overtime is occasionally required in emergencies. To increase of level of awareness among the personnel and consumers / users, hence all the staff including general workers are been trained. According to Mr, Zulkiflee, they have their own study or training centre namely PSDC at Bayan Lepas, Penang. Although all the staffs are been trained but only the operators or

technicians will carry out the operations task. The staff been trained in operating and maintaining the onsite water treatment system. They have been given provision period of learning theory but more on practical learning of the water treatment system and management. Consumers or users are encourage to participate in the awareness campaign that provided by PBA for surrounded users such as Tanjung Bungah, Teluk Bahang and Batu Ferringhi. Every year they will conduct safety awareness training to the public, thus they will invite surrounded hotel management representative, school representative and residents such as villagers and villager's representative. The basic knowledge of the operation, hazard that might be occurring at treatment plant are given through the training or campaign. They will teach how to cope with the hazard that might be occurring for example, the chlorine gas leakage may occur. If this case happened, the infected area may spread widely in approximately 2 kilometers.

Financial Status

The expenditures cost of the water treatment system at Batu Ferringhi treatment plant was almost equal to the revenue / income generated. The water that provide to the users are charging the consumers roughly RM 0.22 cents per 10,000 liters and the operation costs RM 0.04 to RM0.08 which is not including administration cost. The maintenance cost of the water treatment system was high. Thus, 40 percents of income was spending for the expenditures in maintenance of water treatment system. Due to the mechanicals and electrical system are the key operations in water treatment system, therefore the maintenance costs that involve are definitely high.

Work Order Control

There are three documentations are available to control the work order at Batu Ferringhi treatment plant, that are Operation Manual, Maintenance Manual and Administration Manual. These three types of documentations as a guideline to monitored the work order of water treatment system. The monitoring of the system was conducted complied with the ISO Standard. The maintenance and operation of the system are also complied with the ISO Standard. The monitoring works are carried out with daily basis. The operation of water treatment system are running 24 hours continuously, thus daily monitoring works are carried out at every two hours.

Level of Service

The quality of the effluent being discharge from the water treatment was maintained in minimum quality. Once the catchment areas have been maintained, the pollutions level will decrease. Therefore, the water was clean comparing with others occupied catchment area. The sludge / effluent discharge from Batu Ferringhi treatment plant can be reused. The sample of effluent are been took by researcher to further research. The effluent can be used to produce bricks that can be used as construction materials with additional chemicals. But the quantity of effluent that discharge from the Batu Ferringhi treatment plant were not sufficient to produced bricks. The reused of the effluents are still under research and development.

Users / Consumers satisfaction

There are no complaints from operation of plant from staffs and consumer / neighboring communities at Batu Ferringhi. Consumers was satisfied with the water supply service that provided by PBAPP. The staffs are satisfied with the current performance of onsite water treatment system. This is because the Batu Ferringhi treatment plant conventional plant which is easier to manage.

❖ CONCLUSION

In this study, analysis and discussion was used to identify the factors that influencing the water treatment performance. The factors that the researcher discussed are operation, maintenance, human resources management (shift, awareness and training), financial status, work order control, level of services, and users / consumer satisfaction factors. The results showed that the performance of water treatment at Batu Ferringhi is satisfied. The treatment plant was achieved the objective of operation to provide portable water service for consumers use. They have successfully supplied clean water to consumers and they are satisfied with the performance of plant operations. The discussed result on several factors showed that the water treatment performance is satisfied. The operations of water treatment system are emphasizing safe, quality and sufficiently practiced. Natural water has been treated in correct manner and complies with the standards.

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