TREATMENT OF ACIDIC RAW WATER USING ANOXIC LIMESTONE SYSTEM

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Specially dedicated to my family;

Beloved parents, Hj Mohd Kusin Abd Hajis & Hjh Jahrah Jelani

Dearest sister and brother, Angah & Adik

for all the love, encouragement and faith…

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ABSTRACT

Sg. Bekok serves as an important water supply resource for the district of Batu Pahat. In recent years, the water supply intakes within Batu Pahat district have been unable to provide sufficient supply of raw water which has lead to water shortages problem. This was due to water quality deterioration undergone by Sungai Bekok that is highly acidic with low pH values and high acidity. Limestone has been widely used in the treatment of acidic water due to its capability of neutralizing acid and removing metals in water. This study investigated the efficiency of limestone treatment in treating acidic water within a laboratory scale anoxic limestone drain. The anoxic limestone drain was basically designed to enhance limestone dissolution and alkalinity generation thus minimizing the potential of armouring which may decrease the rate of acid neutralization. Actual raw water from two different locations within Sg. Bekok catchment was used in the experiment treated by 30 mm diameter of 112 kg of limestone. The condition under which the pH increases, acidity decreases, alkalinity produced and metals removed in the anoxic limestone drain has been determined in comparison to open limestone channel performance. pH was significantly increased from initially 3.27-4.09 to 6.49-6.67 after flowing through the anoxic drain in 10 minutes of contact with the limestone. Acidity was reduced from 73-99 mg/L as $CaCO_3$ to 17-19 mg/L as $CaCO_3$ as pH were raised to reach near neutral levels. Iron and aluminium were also removed in the anoxic limestone drain. Anoxic limestone drain was found to perform better than the open limestone channel.

ABSTRAK

Sg. Bekok merupakan sumber bekalan air yg utama bagi daerah Batu Pahat. Sejak kebelakangan ini, beberapa *intake* bekalan air di daerah ini tidak dapat membekalkan sumber air mentah yg mencukupi sehingga menyebabkan masalah kekurangan bekalan air akibat daripada masalah kualiti air di Sungai Bekok yang sangat berasid dengan pH yg amat rendah dan keasidan yang tinggi. Batu kapur telah digunakan secara meluas bagi rawatan air berasid kerana berpotensi untuk meneutralkan keasidan air serta menyingkirkan logam daripada air. Kajian ini dijalankan bagi mengkaji keberkesanan batu kapur dalam merawat air berasid melalui penyediaan saluran batu kapur *anoxic* berskala makmal. Saluran batu kapur *anoxic* tersebut telah direkabentuk bagi meningkatkan keterlarutan batu kapur dan penghasikan kealkalian bagi meminimumkan potensi berlakunya *armouring* yang dapat mengurangkan kadar peneutralan asid. Air mentah daripada dua sumber di sekitar Sg. Bekok telah digunakan bagi tujuan eksperimen yang dirawat dengan batu kapur berdiameter 30 mm sebanyak 112 kg. Keadaan di mana pH meningkat, keasidan menurun, kealkalian dihasilkan and logam disingkirkan di dalam saluran batu kapur *anoxic* telah dikenalpasti dan dibandingkan dengan saluran batu kapur terbuka. pH didapati telah meningkat daripada 3.27-4.09 kepada 6.49-6.67 setelah melalui saluran batu kapur tersebut selama 10 minit. Keasidan berkurang daripada 73-99 mg/L sebagai $CaCO_3$ kepada 17-19 mg/L sebagai $CaCO_3$ apabila pH telah ditingkatkan kepada tahap hampir neutral. Ferum dan aluminium juga didapati berjaya disingkirkan oleh saluran batu kapur anoxic. Saluran batu kapur *anoxic* juga didapati menunjukkan prestasi yang lebih baik berbanding saluran batu kapur terbuka.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Al	-	Aluminum
ALD	-	Anoxic Limestone drain
AMD	-	Acid Mine Drainage
Ca^{2+}	-	Calcium ion
$CaCO_3$	-	Calcium Carbonate
Fe	-	Ferum
FeS_2	-	Pyrite
H^+	-	Hydrogen ion
H_2O	-	Water
HCO_3^-	-	Bicarbonate ion
Mn	-	Manganese
Ni	-	Nickel
OA	-	Organic acid
OLD	-	Oxic Limestone Drainage
OPC	-	Open Limestone Channel
Pb	-	Lead
Q	-	Volumetric flow rate
Zn	-	Zinc

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 Preamble

Water resources development has been a catalyst for socioeconomic development of the country. However, water situation for some parts of the country has changed from one of relative abundance to one of scarcity. The growth in population and expansion in urbanization, industrialization and irrigated agriculture are imposing growing demands and pressure on water resources, besides contributing to rising water pollution. The fact that the volume of water available is finite and the demand for water is increasing, indicates that the supply approach in water management is unsustainable.

Water is a global issue. The World Water Vision Report (2000) acknowledged that there is a global water crisis. The crisis is not about having too little water to satisfy our needs. It is a crisis of managing water so badly that billions of people and the environment suffer badly. The world's supply of fresh water is also under great stress. The global consumption of water is doubling every 20 years due to the growth of the human population. If the trend persists, by the year 2025, the demand for fresh water will rise by 56 percent. In that situation, as many as two-thirds of the world's population will face a serious water shortages.

In the context of this country, the state governments are responsible for the development, operation and maintenance of water supply. Since water is important for socio-economic development of the nation, the Federal Government provides soft loans to State Governments for public water supply infrastructure and grant for rural water supply development. In order to ensure sustainable water resources and efficient water supply services, the Federal Government is moving towards greater involvement in the integrated water resources and water supply services, which is a good indication for water management in the country. The national water supply coverage in 2003 is 93 per cent, that is 97 and 86 per cent for urban and rural areas, respectively. The estimated population in 2003 is 24.5 million with urban-rural proportion of 60:40 as reported by Asia Water (2004).

Nevertheless, there has been an increasing number of river water quality deterioration over the country in recent years. The deterioration is mainly due to domestic wastewater, surface runoff from urban areas, discharges from restaurant, wet markets and food courts, pollution from agricultural and land clearing activities, suspended solids and silts from earthwork and sand mining, the non-point polluting sources (NPS) that are not under the jurisdiction of Environmental quality Act (EQA), 1974. This deteriorating trend of river water quality had prompted this country to look into more effective means of improving them in a holistic manner so as to sustain their beneficial uses and demands.

1.2 Background of Study

The studied area of Sg. Batu Pahat catchment, covers an area of 1944 km^2 which consist of two main tributaries namely Sg. Simpang Kiri and Sg. Simpang Kanan. As for Sg. Simpang Kanan, the two main tributaries are Sg. Bekok and Sg. Sembrong with a catchment area of 645 and 273 km^2 respectively (SMHB, 2000).

Sg. Bekok is identified as among of the large streams of the district of Batu Pahat with an approximately 20 km length from its source of Bekok Dam to the town of Yong Peng. Its catchment has a total area of 645 km^2 and the upstream part of the basin is controlled by the Bekok Dam. The provision of the Bekok Dam is essentially important for the control of floods within the catchment which in turn, ensuring ultimate consumption of the river water for clean and safe water supply.

In addition, Sg. Bekok serves as an important water supply resource for the district of Batu Pahat to yield sufficient amount of raw water to four water treatment plants located nearby the stream (SAJ Holdings, 2003). It provides a direct supply of raw water to Yong Peng 2 and 3 Water Treatment Plant, whereas the Sri Gading and Sembrong Water Treatment Plants receive their raw water resource from an artificial lagoon of Sg. Sembrong that is constructed for the purpose of production capacity storage in addition to water quality stabilization prior to being used.

The supplies of water for Batu Pahat district are drawn from the two main tributaries of Sg. Simpang Kanan and Sg. Simpang Kiri together with their tributaries of Sg. Bekok and Sg. Sembrong. The intakes and capacity are as shown in Table 1.1.

Table 1.1: Intakes and Capacity of Sungai Bekok and Sg. Sembrong

Intakes	Capacity	River
Sri Gading	72 MLD	Sg. Bekok
Parit Raja	68 MLD	Sg. Sembrong
Yong Peng	81 MLD	Sg. Bekok

Source: SAJ Holdings (2005)

Nevertheless, treated water supply in the district has been adversely affected by poor water quality and insufficient release from the dams. Water supply in Batu Pahat has been unable to meet demand due to factors such as increasing demands, conflicting requirements of flood control function, pollution in the river, low pH and below average rainfall in the catchment (SMHB, 2005).

1.3 Problem Statement

In recent years, the water supply intakes within Batu Pahat district have been unable to provide sufficient supply of raw water which has lead to water shortages problem. This is a result of water quality deterioration undergone by Sungai Bekok with high concentration of iron (1-2 mg/L) and pH values as low as 2.5 (highly acidic water) which exceed the limits set out by the Environmental Quality Act's standard for Class II rivers, corresponding to rivers suitable for production of potable water (SAJ Holdings, 2005). This has caused interruptions in the operation of water treatment plants at Yong Peng 2 & 3 as well as Sri Gading and Parit Raja to produce sufficient potable water to the district of Batu Pahat. The deterioration of the water quality started in the middle of 1990's as a direct result of intensive drainage activities in the riparian lowland between the Bekok Dam and the town of Yong Peng (SAJ Holdings, 1999).

The iron and acidification problem originates from a combination of high pyrite content in soil and as a consequence of intensive land development and drainage of agricultural areas. A study carried out by Universiti Teknologi Malaysia indicated that the drainage of the riparian lowland has initiated pyrite oxidation, primarily during dry periods due to lowering of the upper ground water level. When the water level is reduced, the pyrite in the soil is aerated and an oxidation process transforms pyrite into acid and sulphate. Although oxidation decreases during wet periods, the same wet periods cause the sulphate and acid to be flushed from the drainage areas into Sg. Bekok (Asia Water & Environment, 2005). The exchangeable pyrite pool in the area is significant and will influence the water quality in Sungai Bekok for another 10-20 years.

The variations in the distribution of landuse within the catchment have been identified to be another contributing factor of water quality deterioration such as palm oil plantation, industries, mixed agriculture, livestock farming and settlements. The potential pollution that may arise from these land uses are typically the result of the use of fertilizers and pesticides, sediments and acid release from acid sulphate soil. Since the main problems are related to acidic water condition, it is control of its sources which should be the concern to such an extent that the water quality of the river can be protected. Liming of acidified water is recognized as a means of treating acidic water as it has a potential of neutralizing acidity, increasing pH and concentration of alkalinity.

1.4 Aim of Study

The aim of this study is to provide efficient on-site treatment system as an alternative solution to acidic raw water problem of Sg. Bekok, Batu Pahat.

1.5 Objectives of Study

The objectives of the study were:

i. To evaluate the effectiveness of anoxic limestone treatment in treating acidic raw water
ii. To compare the performance of oxic and anoxic limestone treatment
iii. To explore the relationship between pH and acidity level and anoxic limestone treatment efficiency

1.6 Scope of Study

The study comprised of experimental study using a laboratory scale anoxic limestone reactor. The raw acidic water used in the experiment was obtained from two different sources namely Bekok Intake and Sembrong Lagoon. The efficiency of anoxic limestone drain was evaluated and compared to open limestone channel in relation to their respective pH adjustment, acidity reduction, alkalinity generation, and removal of iron and aluminium.