CURRENT PHOSPHATE DISCHARGE OF INANAM RIVER, SABAH

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Always............

Kanageswari Krishnan
CURRENT PHOSPHATE DISCHARGE OF INANAM RIVER, SABAH

ABSTRACT

This study analyzed data collected from four chosen sites along the Inanam River of Sabah between 14th December 2004 and 5th February 2005 to understand the relationship between stream discharge and phosphate concentration and to determine the phosphate discharges along the river. In addition, the effect of a river tributary (Kitobu stream), running water from agricultural land, to phosphate discharge of the river was also examined. Stream discharge was measured using the velocity-area method and phosphate concentrations (as total phosphorus) were analyzed with colorimetric method (Ascorbic Acid Method). Stream discharge was negatively related to phosphate concentration at Sites 1 and 2, indicating point sources of phosphate. At Sites 3 and 4, stream discharge was positively related to phosphate concentrations indicating non-point sources of phosphate. Phosphate discharges increased from upstream Site 1 (0.0018 g s\(^{-1}\) to 0.0066 g s\(^{-1}\)) to Site 2 (0.077 g s\(^{-1}\) to 0.7448 g s\(^{-1}\)) and to Site 3 (0.1277 g s\(^{-1}\) to 1.5744 g s\(^{-1}\)) downstream. Phosphate discharge from agricultural land, at Site K, ranged between 0.006 g s\(^{-1}\) to 0.1389 g s\(^{-1}\). Site K has been identified as not contributing to high phosphate discharge at Site 3.
LUAHAN FOSFAT SEMASA DI SUNGAI INANAM

ABSTRAK

Kajian ini telah dijalankan dalam tempoh 14 Disember 2004 hingga 5 Februari 2005 untuk memahami hubungan luahan sungai dengan kepekatan fosfat dan untuk menentukan luahan fosfat di empat stesen terpilih di sepanjang Sungai Inanam, Sabah. Selain itu, kesan sebuah anak sungai (Sungai Kitobu) yang mengalir dari kawasan pertanian, ke atas luahan fosfat di Sungai Inanam turut dikaji. Luahan sungai telah ditentukan dengan menggunakan kaedah halaju-luas manakala kepekatan fosfat ditentukan dengan menggunakan kaedah kolorimetri (Kaedah Asid Askorbik). Kedua-dua nilai ini kemudiannya didarab untuk memperolehi nilai luahan fosfat. Peningkatan luahan sungai didapati menurunkan kepekatan sungai di Stesen 1 dan 2, menunjukkan punca titik fosfat. Di Stesen 3 dan 4, peningkatan luahan sungai meningkatkan kepekatan fosfat menunjukkan sumber pencemaran bukan titik. Secara amnya, luahan fosfat meningkat dari Stesen 1 di hulu hingga ke Stesen 3 di hilir. Julat nilai luahan fosfat di Stesen 1, 2 dan 3 masing-masing adalah 0.0018 g s⁻¹ hingga 0.0066 g s⁻¹, 0.077 g s⁻¹ hingga 0.7448 g s⁻¹ dan 0.1277 g s⁻¹ hingga 1.5744 g s⁻¹. Luahan fosfat di Stesen K (Sungai Kitobu), adalah dalam julat 0.006 g s⁻¹ hingga 0.1389 g s⁻¹. Stesen K didapati tidak menyumbang kepada luahan fosfat yang tinggi di Stesen 3.
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<tr>
<td>P</td>
<td>phosphorus (phosphates)</td>
</tr>
<tr>
<td>TP</td>
<td>total phosphorus</td>
</tr>
<tr>
<td>ECD</td>
<td>Environmental Conservation Department</td>
</tr>
<tr>
<td>DOE</td>
<td>Department of Environment</td>
</tr>
<tr>
<td>DIP</td>
<td>dissolved inorganic phosphorus</td>
</tr>
<tr>
<td>DOP</td>
<td>dissolved organic phosphorus</td>
</tr>
<tr>
<td>nm</td>
<td>nanometer</td>
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<tr>
<td>m³ s⁻¹</td>
<td>cubic meter per second</td>
</tr>
<tr>
<td>m s⁻¹</td>
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</tr>
<tr>
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CHAPTER 1

INTRODUCTION

1.1 STUDY BACKGROUND

Interest in water and related problems has grown markedly throughout all segments of global society in the last half of the 20th century. An understanding of the occurrences, distribution and movement of water is essential in various divisions of sciences. In short, water is an important element in the physical environment (Elliot and Ward, 1995).

Hydrology has an important role in water quality. Surface runoff pictures the hydrological processes of a small catchment in a better way than any other measurement (Elliot and Ward, 1995). Hydrological processes and concepts help explain the water quality processes and provides a better understanding on the relationships of the environmental systems with human impacts.

A river acts as a temporary storage reservoir in hydrological cycle (Elliot and Ward, 1995). According to the Department Of Environment (1995), major contributors for the river pollution in Malaysia are silt, due to soil erosion and organic pollution from sewage and animal waste. In 1995, a number of 3141 industries were
Environment, of which includes food and beverage industries (30.9%), chemical industries (13.5%) and textile (10.4%).

Based on the information that water quality depends also on water flow (Elliot and Ward), the study on phosphate discharge in Inanam River was carried out. One way to estimate loadings of phosphorus in a watershed is to monitor quality and quantity of a river water (Raj and Trivedi(a), 1992). Basically, a simple understanding on point and non-point sources of phosphorus is important to relate phosphate concentrations with stream discharge.

Phosphorus occurs in natural waters and wastewaters almost exclusively as phosphates (APHA, 1989). Phosphorus is usually found as orthophosphates (H$_2$PO$_4^-$) and the most common phosphorus-containing mineral is apatite. In springs, streams close to source and rainwater, orthophosphate ion recedes with respect to the other combined forms of phosphate. In sewage-polluted watercourses, orthophosphate fraction usually predominates (Hellmann, 1987). In this study, phosphate is studied as total phosphorus (TP) and the term phosphate and phosphorus (P) are used interchangeably.

This study was carried out in order to identify the extent to which the Inanam River is enriched with phosphorus and to examine short-term trends in variability of phosphorus contents in the river. The enrichment of surface waters with phosphorus may have large and undesirable impact on their trophic state, usage and appearance. Symptoms of eutrophication in rivers are of considerable social and economic concern in many regions (Muscutt and Withers, 1996). Meybeck (1982) in Muscutt
identified as significant were pollution sources by the Malaysian Department of Environment, of which includes food and beverage industries (30.9%), chemical industries (13.5%) and textile (10.4%).

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and Withers (1996) estimated over 20 million tonnes of phosphorus is transported by world rivers each year. In short, this short-term study was carried out to provide a very basic understanding of river water quantity-quality relationships.

1.2 **OBJECTIVES**

Three objectives were outlined to achieve the aim of this study, which are:

i. To understand the relationship between phosphate concentration and stream discharge.

ii. To determine phosphate discharge of Inanam River.

iii. To determine the effect of a river tributary (Kitobu Stream), running water from agricultural land to the phosphate discharge of Inanam River.

1.3 **STUDY AREA**

Headwaters of Inanam River originate from several tributaries upstream at the Kiansom catchment, and the river flows west into Likas Bay (ECD, 2002). The river’s overall Water Quality Index (WQI) is 83 and thus classified as a clean river. The river is classified in the Class II based on the Proposed Interim National Water Quality Standards for Malaysia (INWQS) indicating suitability for domestic water supplies (DOE, 1999).

The reported mean baseflow of Inanam River is 0.198 m$^3$ s$^{-1}$ at Kampung Kabuni, while the maximum discharge estimation reaches up to 55 m$^3$ s$^{-1}$ (ECD,
2002). The data presented by Khalid (2000) shows that generally, phosphate concentrations of the river decreased with increased discharge.

Inanam River passes Inanam town (commercial area) and also a number of villages. The river is of particular interest for this study because of the activities taking place along the river; especially livestock farming and agricultural activities. Other activities include fishing and settlement. Therefore, the possible sources of phosphates in it might be the direct discharge of wastewater from livestock activities and riverside settlements.
CHAPTER 2

LITERATURE REVIEW

2.1 THE HYDROLOGIC CYCLE

Water occurs in the atmosphere and above and below the earth's surface as liquid (streams, lakes, oceans, groundwater, etc.), solid (snow, hail, ice, etc) and gas (water vapour). The hydrologic cycle is a global system that supplies and removes water from the earth's surface (Cornwell and Davis, 1998). The hydrologic cycle describes the continuous cycling of water from atmosphere to earth and oceans and back again, representing a series of storage places and transfer processes between land and sea (Elliot and Ward, 1995).

Precipitation, primarily as rain and snow, transfers water from the atmosphere to the land surface, thus causing run off as surface water or other alternative pathways. Evapotranspiration directly returns a considerable fraction of precipitation to the atmosphere. Water on the ground, lake and stream surfaces evaporates directly back to the atmosphere (Drever, 1997).

Precipitation reaching ground, reaches stream channel or groundwater via several pathways, including overland flow, groundwater flow, subsurface flow or
overland flow. Soil absorbs rainfall, which then reaches groundwater and then discharged to streams over a long period of time. The maximum rate at which soil absorbs rainfall is termed infiltration capacity. The entering of groundwater to stream channel causes baseflow or dry weather flow of a river. The hydrological cycle thus interconnects various types of water bodies, including flowing water, lakes, reservoir and groundwater, with many intermediate natural and artificial water bodies (Allan, 1995; Raj and Trivedi (a), 1992). The runoff process is represented in the following Figure 2.1.

Figure 2.1 Diagrammatic representation of the runoff process (adapted from Ward, 1975).
2.2 SURFACE WATER

The potential for surface runoff exists when the rate of water application to the ground surface exceeds the rate of infiltration into soil (Elliot and Ward, 1995). Running waters are very diverse, ranging from small streams to great rivers. They occur under various conditions of climate, vegetation, topography and geology (Allan, 1995).

Water moves downhill via various routes (Allan, 1995). As water reaches dry soil, application and infiltration rates are almost similar. As the soil gets wetter, infiltration rate decreases and at some extent, surface water application rate exceeds infiltration rate. Thus, surface runoff is initiated (Elliot and Ward, 1995).

Main sources entering surface water systems vary from one location to another. This includes direct precipitation to the water body, surface runoff from storm events, snowmelts, flows from groundwater aquifers, interflow, subsurface drainage and return flows from water used for domestic, commercial, industrial, mining, irrigation and thermoelectric power generation purposes (Elliot and Ward, 1995).

The attributes of precipitation which have the most influence on runoff processes include type and amount of precipitation, duration of precipitation event, variation of precipitation intensity during the event and spatial changes in the precipitation. Runoff is also dependent on watershed factors such as size, topography, shape and geology of the watershed and also soil and land use at the watershed (Elliot
and Ward, 1995). This dependency affects its rate and chemical composition (Allan, 1995).

2.3 Rivers and Streams

Streams and rivers are made up by stormflow as a consequence of precipitation and groundwater exfiltration or baseflow. Groundwater exfiltration or baseflow is the dry weather flow consequential from the leaching of groundwater out of stream banks (Cornwell and Davis, 1998). Estimation of the amount of water discharged by rivers to world’s oceans range between 32 and $37 \times 10^3$ km$^3$ per year. Greatest runoff occurs in tropical and subtropical areas because these areas receive greatest rainfall (Allan, 1995).

Most rivers are perennial, flowing even when there is no rainfall, while others are intermittent rivers, whose flow is affected by rainfall. In wet regions, the occurrence of gaining streams are usual. Gaining streams are recharged by groundwater. However, in arid regions, streams tend to recharge groundwater. These streams are called losing streams. In some cases, the same river can be gaining during low flows and losing during flood occasions (Allan, 1995).

2.3.1 Discharge

Flow is the volume of water moving past a point in a unit of time (cubic meters per second, m$^3$ s$^{-1}$) (Cornwell and Davis, 1998). Discharge is the total volume of water moving past a point (Allan, 1995). The three main approaches in the measurement of
discharge involve the velocity-area method, the use of control structures such as flumes and weirs, and dilution methods (Finlayson et al., 1992; Ward, 1975).

a. **Velocity-area method**

The discharge of a river, $Q$, is measured by multiplying the cross-sectional area of the river ($W$) with its depth ($D$) and current velocity or speed of water in the channel ($U$), which gives:

$$Q = WDU$$ (2.1)

The typical method is to divide the cross section of the stream into segments and then to measure the velocity and area for each segment. The discharge is the summations of estimated discharge for each segment (Allan, 1995).

b. **Weirs and flumes**

An alternative approach to measure discharge is installation of weirs or flumes (Allan, 1995). Measurement by this mean is usually done on streams where physical obstruction in the channel is permissible (Ward, 1975).

c. **Dilution gauging**

Dilution gauging is a direct measurement of discharge. This method is done by injecting an aqueous solution of a tracer into the stream and then measuring its degree of dilution at an appropriate distance downstream (Ward, 1975). The types of tracer
used may vary. Chemical salts, dyes and radioactive materials, to name a few, are some examples of suitable tracers (Herschy, 1985).

Dilution gauging is suitable for use in rapid, turbulent waters of mountain streams, beneath an ice cover, in closed pipes and in lowland rivers. Two ways of dilution gauging are constant-rate injection and instantaneous injection or pulse integration. Constant-rate injection is carried out by injecting a tracer at a constant rate for a given period of time. Instantaneous injection is the injection of a known volume of tracer instantaneously (Suresh, 1997; Herschy, 1985; Ward, 1975).

2.4 **STREAMWATER CHEMISTRY AND NUTRIENTS**

Unlike seawater, river water varies substantially in its chemical composition (Allan, 1995). The chemistry of water in streams differs markedly according to several factors. Although the major influences on the water chemistry are the closeness to sea and nature of the geology, trace organic and inorganic substances can be brought to a pristine catchment after being emitted into atmosphere from sources far from river (Best, 1997).

The weathering of rocks is the major determinant of river water chemistry. However, water quality varies with geology, and with the magnitude of inputs via other pathways including rain water, volcanic activity and pollution (Allan, 1995; Langmuir, 1997).
REFERENCES


