Monsoonal distribution of phosphate within Tallo Estuary, South of Sulawesi

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Abstract. Phosphate is one indicator of water fertility and is needed to support the life of organisms, especially phytoplankton. The main source of phosphate in the waters naturally originates from the processes of decomposition, weathering or decomposition of plants and comes from the remains of dead organisms. Besides this phosphates in coastal areas are sourced from rivers that carry waste from land, so phosphates in the river mouth are larger than the surrounding waters. The purpose of this study was to describe the pattern of phosphate distribution in the West and East seasons in the Tallo estuary, Makassar using hydrodynamic and distribution models of pollutants. The results of this study indicate the pattern of spreading phosphate in the study site is strongly influenced by oceanographic conditions of the waters.

1. Introduction
Estuary is a unique habitat because it is a meeting place between seawater and freshwater. But coastal areas also often get ecological pressure in the form of pollutants sourced from human activities. The abundance of pollutants in coastal areas is a serious threat to the sustainability of marine fisheries. The accumulation of waste that occurs in coastal areas, mainly due to the high population density and industrial activities [1]. This condition was allegedly also occurring in Tallo Estuary waters.

The Tallo River Estuary is one of the largest river estuaries in the northern part of Makassar City. The density of activity along the Tallo River has caused many rivers to carry waste from industry and domestic activities that eventually accumulates and pollutes the estuary area. The amount of waste sourced from household activities in the form of organic materials such as phosphate is thought to reduce the quality of water in this region.

Biological and physical processes determine the distribution of several forms of phosphate in the waters [2]. Generally phosphates in the waters are in the form of orthophosphate are micronutrients that affect primary water production [3][4]. At high concentrations it will cause eutrophication. Furthermore, if the availability of phosphate in the waters is supported by the availability of potassium and magnesium ions it will cause a "blooming" of algae. In anaerobic conditions "blooming" will cause the death of fish followed by the formation of HS, NH and inhibited photosynthesis. One of the factors causing high concentrations of nutrients in waters is the circulation of water masses. Closed waters tend to have a circulation of water that is not smooth, allowing for increased nutrient concentrations [5].

In addition, water dynamics due to current, tide and wave influence the presence of nitrate and phosphate in waters [6]. The concentration of nitrate and phosphate at low tide conditions has a higher value than the conditions at high tide. This is because the receding conditions will bring seawater masses
from nearshore waters to the open sea, so that the mass of sea water is reduced and organic waste carried by the river flow will be greater [7]. This study aims to determine the pattern of phosphate distribution in the West and East seasons in the estuary of the Tallo River, Makassar.

2. Methodology

2.1. Location and time
Field observation was conducted in two periods, namely the West and East Monsoons. The research area is administratively in Makassar City in geographically position of 5°5’01”-5°6’33” N and 119°26’43”-119°25’13” E. Specifically, the research location is the Tallo Estuary region which is still affected by the tides, namely at the mouth of the Tallo River in Ujung Tanah District, north of Makassar in the position of 5°6’09” S and 119°26’59” E up to the Tello bridge in Tamalanrea District in position of 5°8’42” S and 119°28’23” E, along 15 km (Figure 1).

2.2. Data
The data used in this study consisted of primary data and secondary data. Primary data is obtained by doing direct measurements in the field, which are current measurements. Phosphate measurements were carried out at the Faculty of Marine Science and Fisheries, Hasanudin University (FIKP-UNHAS) oceanographic chemistry laboratory while secondary data were obtained from relevant agencies in the form of maps, water depth data (bathymetry), and tidal data.

2.3. Model design
The hydrodynamic model was created as a basis for describing the process of mixing between water and sediment, the chemical processes that occur in the transition zone between fresh water and the sea and various biological processes that occur. The data used are the coordinates of the research location, currents, wind, bathymetry and tides. The equation used is based on hydrodynamic equations that are built from several equations, namely the momentum equation, continuity equation, mass equilibrium equation [8][9].

The model boundary is made open boundary with finite element and number of elements 6021, the area of the model is 14.993 km2 and the distance from the mouth of the estuary to the outer boundary is
2.8 km. The model is simulated in two monsoons, West and East monsoons at high tide and low tide with a simulation period of 15 days.

3. Results and discussion

3.1. Phosphate (PO₄)
Phosphate is one of the important nutrient compounds in water. Phosphate will usually be adsorbed by phytoplankton and so on will enter the food chain. Based on observations in Tallo Estuary in the western monsoon the range of phosphate content in Tallo Estuary at high tide is 0.46-2.67 mg/l and 0.86-2.43 mg/l at low tide. In the East monsoon the phosphate content at high tide ranges from 0.66-1.15 mg/l and at low tide 0.28 - 1.21 mg/l. Distribution of phosphate content in Tallo Estuary is fully presented in Figure 2. Phosphate content in Tallo Estuary is generally seen that in the west monsoons is higher than in the East monsoon. This is thought to be due to the large amount of waste input and the destruction of organic material and phosphate minerals carried by water entering the Tallo River.

![Figure 2](image-url) Phosphate content (mg/l) in Tallo Estuary waters a) west monsoon, b) East monsoon.

Phosphate content in the study site has exceeded the environmental quality standard of 0.016 mg/l. Samawi [10] said that the Tallo River watershed through residential and industrial settlements estimated the amount of waste load flowing on the Tallo river flow is estimated at 1,023,528 tons of organic material per year, of which around 438,379 tons of N and 73,385 tons of P per year. This number has increased in the 2003 - 2005 period, especially phosphate which indicates that the use of detergents that are difficult to decompose is still quite high in the city of Makassar.

The results of hydrodynamic model simulation based on seasons and tidal patterns at the mouth of the Tallo River show that the current pattern at low tide moves towards the West with an average speed of 0.40 m/sec, while at low tide toward the highest tide the current pattern moves from the direction West to the east and along the beach towards the river. The pattern of current movement at the mouth of the Tallo River is not only influenced by tides but is also influenced by the direction and speed of the wind.

The results of tidal verification in the West Monsoon between the results of the model with the tidal data from Bakosurtanal showed a correlation value of 94.87%. This means that the results of the model approach the conditions that occur in the field (Figure 3).
Phosphate distribution model simulation is done from the first hour to the 360th hour (15 days). The initial concentration for the simulation is taken from the measurement of the phosphate concentration carried out in the laboratory, with several assumptions namely the decay value and the concentration of the point source is constant. The model area covers station 4 (119° 17' 28" E - 5° 7' 05" S) to station 13 (119° 25’ 13” E - 5° 6’ 33” S) located at the mouth of the Tallo River.

3.2. West monsoon
Simulations in the West Monsoon begin at low tide, with a phosphate concentration of 0.26 mg/l at high tide and 1.85 mg/l at low tide. Water discharge is 233.91 m3/sec with a current speed of 0.25 m/sec.

The pattern of phosphate distribution with a constant concentration of input indicates that there is a tendency for an increase in concentration in the model area. This of course will cause serious pollution problems when the assimilation capacity in the river mouth is exceeded. This condition will be exacerbated by oceanographic factors that tend to spread pollutants in the waters. Slow current velocity with a longer tidal duration compared to at low tide and water depth factors cause the water mass to be held at the mouth of a river mouth. Goldberg [11] states that the assimilation capacity of waters is determined by the morphology and dynamics of the waters as well as the type and amount of waste that enters the waters.

In the West monsoon the phosphate distribution pattern follows the pattern of currents moving towards the West. Some currents converge at the mouth of the estuary causing the phosphate to partially enter the river. The simulation is terminated at high tide after 5 days. From the picture, it can be seen that phosphate is spread in almost all areas of the model where there is a buildup of phosphates in the mouth of the estuary mouth around stations 5 and 6. Current patterns that tend to move to the East partly bring the phosphate back into the estuary and are added with input coming from the river so that there is a tendency piled up at the mouth of the Tallo river (Figure 4).

Phosphate concentration from observations in the field shows the value of the seawater quality standard Decree of the Minister of the Environment No. 51 of 2004 is 0.016 mg/l [12].
3.3. East monsoon
In the East Monsoon the simulation begins at low tide, with a phosphate concentration of 0.83 mg/l at high tide and 0.91 mg/l at low tide. Water discharge is 89.82 m³/sec with a current speed of 0.12 m/sec.

The phosphate distribution pattern is concentrated in the mouth of the estuary and moves west along the coastline (Figure 5). In contrast to conditions in the Western season, phosphate concentrations at the end of the simulation do not spread in the model area. This is presumably due to the low flow velocity and volume of water flowing out of the river mouth.

From the results of simulation models indicate that both the West and East monsoons occur a tendency to build up of phosphates in the mouth of the estuary due to oceanographic ocean conditions. This allegedly also applies to various other types of pollutants. Therefore a management effort is needed so that the amount of waste load entering the Tallo River can be reduced so that the assimilation capacity of the waters is met.
4. Conclusion

Phosphate content in Tallo Estuary in the west monsoon is higher than in the East monsoon. In the western monsoon the range of phosphate content in Tallo Estuary at high tide is 0.46-2.67 mg/l and 0.86 - 2.43 mg/l at low tide. In the East monsoon, the phosphate content at high tide ranges from 0.66-1.15 mg/l and at low tide 0.28-1.21 mg/l. The results of the model show the pattern of phosphate distribution and tend to increase in the mouth of the river mouth and spread towards the sea in accordance with the pattern of currents that occur at the study site.

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