Retrospective Eutrophic Assessment of the NOWPAP Coastal Areas to Identify Hot Spots on the Viewpoint of Harmful Algal Blooms

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1. Introduction

NOWPAP area encompassed by 33-52°N and 121-143°E is a semi-enclosed marginal sea surrounded by five countries. It is shallow with average depth of less than 200meters in most of the western and southern part, but the eastern NOWPAP whose average depth is about 1mile. Kuroshio warm current transports heat energy, and dissolved nutrients could be supplied from the land whose population is approximately 560millions (UNEP/NOWPAP/CERAC/FPM 3/13, 2005).

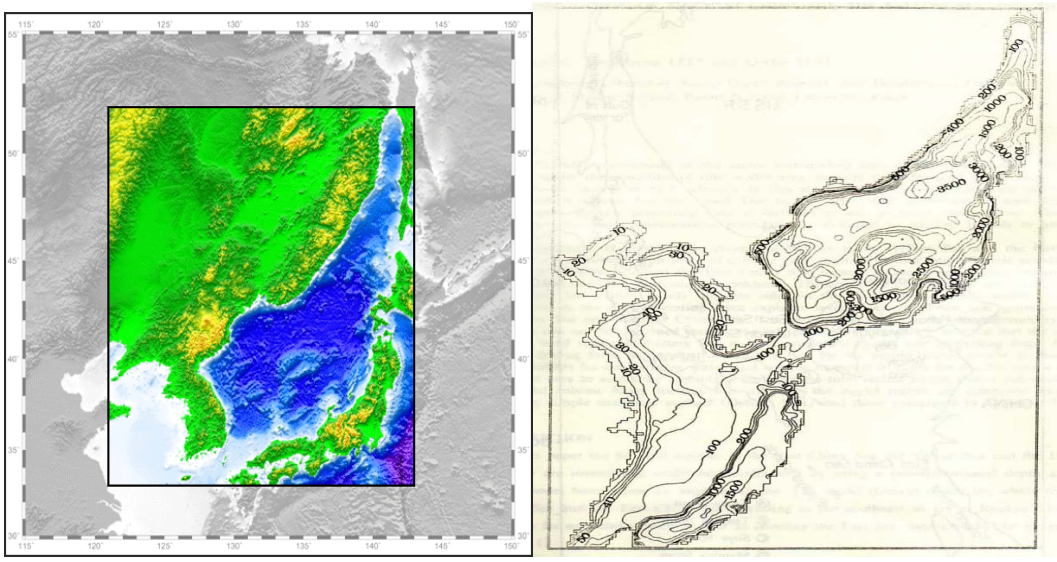

Fig. 1. Area of the NOWPAP region (33-52°N and 121-143°E) and bathymetries(in meter).

This is why the NOWPAP seas are vulnerable to coastal eutrophication by terrestrial and atmospheric pollutant inputs partially by such high anthropogenic loads and partially by the geographic characteristics of land altitude which cause the assemblage of river runoffs into the WNS, and land-enclosed ENS. Such on-going increase of terrestrial effluents and domestic

wastewaters into the NOWPAP Seas has degraded the water quality of high eutrophic state. This degradation will be maintained due to the increase of population and high economic growth. Such consecutive increase of terrestrial effluents all along the coast of NOWPAP Sea has been induced a significant eutrophicantion and subsequent harmful algal blooms (HABs). As one of action plans for the conservation of north Pacific marine ecosystem, it needs to assess the water quality and should take relevant management actions to keep the water quality from an unconcerned change for the worse. Here, environmental risk assessment has been carried out to assess the eutrophic state and to identify hot spots in association with HABs.

2. Material and methods

The concentration of nutrients and outbreaks of harmful algal blooms (HABs) are good parameters to assess the risk of environment. Most of the nutrients and HABs data and information cited herein have been collected from national reports of four countries submitted to NOWPAP CEARAC and POMRAC. Besides, environmental data and information from the regular monitoring of the member countries and archives on oceanographic and environmental changes are also cited. According to oceanographic properties and anthropogenic pollution loads, the NOWPAP sea can divide into the western NOWPAP sea (WNS) consist of the Bohai Bay, Yellow Sea and south sea of Korean peninsula, and the other eastern NOWPAP sea (ENS) composed of the East/Japan Sea extending to Tartar Strait.

To conduct retrospective risk assessment, the working procedures have taken four steps such as problem formulation, retrospective and prospective risk assessment, and risk management (GEF/UNDP/IMO, 1999). At the first phase of problem formulation, NOWPAP Sea is decided as to the target area, and nutrients such as nitrogen and phosphate are chosen as suspected agent. The endpoint to be considered in the target is the outbreaks of harmful algal blooms (HABS). At the second phase of retrospective risk assessment, nutrients levels and the outbreaks of HABs have been investigated to assess the nutrients as one of risk agents causing HABs in this sea. For prospective risk assessment, the sources of risk agent, the likely routes of exposure, and the likely critical levels were estimated according to the retrospective risk assessment.

Taking the variability in measured environmental concentrations into account, here quantify the risk quotients (RQs) by using Hadaka's eutrophic index (Hanaoka et al., 1972). This index is applied to assess the nutrient level and subsequent susceptible capability of initiating red tides. This index is the eutrophic value of COD 1ppm x DIN(7.14㎍-at/ℓ=0.14㎎/ℓ) x DIP (0.48㎍-at/ℓ=0.02㎎/ℓ) divided by 3.43, by which the index 1 means the eutrophic level of water quality is quite enough to initiate the red tide. At the last phase of risk management, hot spots in association with HABs are determined based on the high nutrients and persistent HABs. Finally the likely route of nutrient loads and haunting zone of HABs have been suggested for the risk management.

3. Results and discussions

According to the national reports on river and direct inputs of contaminants into the marine and coastal environment in NOWPAP region, the major sources of water pollution were domestic wastewater and industrial effluents (UNEP/NOWPAP/CERAC/FPM 3/13, 2005). Based on national reports (NOWPAP POMRAC, 2006), the river and direct inputs of contaminants into NOWPAP coast and seas are enough to cause eutrophic pollution, especially in the WNS where is highly vulnerable to anthropogenic pollutants.

The nitrogen and phosphorus concentration in the WNS and ENS have shown high due to much of terrestrial uptake and shallow water depth of no good exchanges with offshore waters (Kim, 2007). In case of ENS, the dissolved nutrients concentration has been relatively low owing to deep water and relatively not much of river runoffs. At this retrospective eutrophic assessment, terrestrial pollutants through river and direct inputs have been playing an important role on the degradation of coastal water quality. The high amount of river runoffs are found at the estuaries of Yangze, Songhua, Huang ho, Yalu, and Han rivers in WNS, and Nakdong, Ishikari, Mogami, Agano, Tumen, and Razdolnaya rivers in ENS. Such configuration of high eutrophic state can tell us that the likely source and routes are attributable to neighboring land by doing casual chain analysis. Based on this retrospective eutrophic assessment, the potential hot spots could be figured out in the estuaries of Huang Ho, Yangze, Yalu, and Han rivers in WNS, and Nakdong estuary, the eastern coast of Kyushu and Honshu, and the transboundary area of Tumen river and Primorski Krai.

With respect to the outbreaks of HABs, harmful dinoflagellate blooms have taken place every year in summer season in the coast of WNS especially in Bohai Bay, Yellow Sea and the south sea of Korean peninsula. In ENS, there were red tides between April to September with peak in June and July along the Japanese Kyushu coast (UNEP/NOWPAP/CERAC/FPM 3/13, 2005). Mass mortalities of fish and shellfish have been observed at the red tides caused by *Heterocapsa circularisquama, Heterosigma akashiwo, Cochlodinium polykrikoides,* and *Noctilluca scintillans* both in WNS and ENS. However in the coast of Eurasian continent of the northern part of ENS, most of red tide events were observed from March to September with the peak in June and July, and caused no damages on marine living organisms. Such frequent HABs have caused massive fish kills, and contaminate seafood with PSP, DSP and ASP toxins. There has been a dramatic increase in the impacts of HABs for the last decade especially in WNS, and that the HABs problem is now become one of serious socio-economic issues in NOWPAP region.

4. Conclusions

The NOWPAP Region comprises semi-enclosed marginal seas situated in both the sub-polar and temperate zones. It has a wide variety of marine life and commercially important fishing

and mariculture grounds. However, industrial wastes, untreated municipal sewage, and nutrients in run-off stimulate eutrophication and subsequent HABs resulted in widespread damages. The NOWPAP programme aims to mitigate the degradation of coastal pollution through the sustainable management and use of the marine and coastal environment by engaging in comprehensive and specific actions to protect marine environment. A retrospective risk assessment is the first step for specific actions to conserve northwest Pacific ecosystem. Well-designed strong prevention actions should be taken to the potential hot spots associated with HABs in order to delay present accelerating eutrophication areas especially the WNS, the most highly populated and industrialized area..

In this regards, NOWPAP member countries are responsible for protecting people from adverse health effects that arise from environmental exposure to contaminants, and also for protecting flora and fauna. It is time to develop cooperative management strategies such as coordinated and collaborative monitoring and marine policy of pollution prevention to secure sustainable production and biodiversity of the northwest pacific.

Keywords: terrestrial pollutants, eutrophication, risk assessment, hot spots, HABs

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