ANALYSIS OF NUTRIENTS OF BALLAST WATER IN CARGO SHIPS AT HẢI PHÒNG PORT

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TÓM TẮT

PHÂN TÍCH MỘT SỐ CHỈ TIÊU DINH DƯỠNG CỦA NƯỚC DẰN TÀU CỦA MỘT SỐ TÀU CHỞ HÀNG TẠI CẢNG HẢI PHÒNG

Nước dằn tàu (ballast water) được sử dụng trong các tàu chở hàng trên biển để duy trì trạng thái ổn định và cân bằng của tàu trong quá trình hoạt động. Tồn tại song song với các hệ sinh vật ngoại lai trong nước dằn tàu là lượng tồn dư của các hoá chất độc hại như các kim loại nặng, các chất hữu cơ có nguồn gốc từ hàng hóa vận chuyển, vật liệu chế tạo hầm tàu, thân tàu, ... được tích tụ dần theo thời gian vận chuyển, khi được xả thải ra môi trường sẽ gây ô nhiễm không nhỏ cho môi trường biển. Trong bài báo này chúng tôi đã nghiên cứu một số đặc tính hóa học, cụ thể là độ muối và dinh dưỡng thông qua hai giá trị tổng P và tổng N của nước dằn tàu lấy tại một số tàu chở hàng tại cảng biển Hải Phòng. Kết quả thu được được so sánh với các tiêu chuẩn của Việt nam và châu Á nhằm đưa ra một cái nhìn sơ bộ về hiện trạng nước dằn tàu tại một cảng biển lớn ở miền Bắc Việt Nam.

1. INTRODUCTION

In order to maintain stability during transit along coasts and on the open ocean, ships fill their ballast tanks with water. While ballast water is essential for safe and efficient modern shipping operations, it may pose serious ecological, economic and health problems due to the multitude of marine species carried in ships ballast water. The transferred species may survive to establish a reproductive population in the host environment, becoming invasive, out-competing native species and multiplying into pest proportions. Moreover, not only organism but also chemical component such as nutrients, salinity and heavy metals in ballast water can bring serious pollution problem to the marine environment [1].

Canada and Australia were among the first countries to experience particular problems with harmful aquatic species, and they brought their concerns to the attention of IMO's Marine Environment Protection Committee (MEPC) in the late 1980's. In 1997 the MEPC adopted Guidelines to address the problem in the form of "Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens". The IMO members were requested to follow these Guidelines, which called for the exchange of ballast water in the open ocean to reduce the risk of transferring harmful species. Finally after many years of negotiations, the International Convention for the Control and Management of Ships' Ballast Water and Sediments was eventually adopted by an IMO Diplomatic Conference in February 2004 [2].

In Vietnam, the problem was well known through communication media since environment pollution is most serious matter nowadays. First steps in ballast water treatment to meet the IMO Ballast Water Management Convention have been started, ocean ship building industry has taken a hand in installing Ballast water treatment system, for example, but in fact, it has yet not entered into force. Researches have been conducted on the current status of ballast water and ballast water management, but very few, and limited only to 2 ports in Southern Vietnam [3]. The aim of this article therefore is to report on the study of some chemical characteristics, specifically the total nitrogen (T-N) and total phosphorus (T-P), of ballast water in cargo ships at Hải Phòng port. Results have been compared to Vietnamese and Asian standards to get an overview of the current status of ballast water in the Northern Vietnam.

2. EXPERIMENTAL

2.1. Chemicals and instruments

- All chemicals H_2SO_4; HNO_3; HCl; H_3PO_4; KH_2PO_4, $NaNO_3$, KNO_2,…are standard chemicals (Merck). Solutions with lower concentrations are prepared from the standard chemicals.
- UV-VIS spectrophotometer (UV-1601) of SHIMADZU-Japan with wavelength range from 400nm to 900nm.

2.2. Sampling and storage

Ballast water samples are collected from cargo ships at Hải Phòng port. All of the ships use segregated ballast water in dedicated ballast tanks which never used for carrying cargo. Hence, the ballast should never come into contact with general cargo and will therefore not be contaminated. In Table 1 is given the list of ships that were sampled. Samples are stored and preserved as required for analysis of each chemical component [4].

Table 1: List of sampling ships

Name of ship	Vessel type	Capacity	Destination	Date of sampling
Hoàng Anh 3	General cargo	16000 tons	Belgium	13/11/2013
Hoàng Anh 1	General cargo	16 000 tons	Belgium	13/11/2013
Hoàng Anh X	General cargo	16 000 tons	Belgium	13/11/2013
Pacific Express	General cargo	8200 tons	Singapore	12/11/2013
Vinacomin	General cargo	7600 tons	Southern-east Asia	26/3/2014
Mỹ Vương	General cargo	14 000 tons	Singapore	26/3/2014
Thịnh Cường Victory	General cargo	7600 tons	Southern-east Asia	14/4/2014

2.3. Method of analysis

Phosphorus has been determined by Molybdenum method. Nitrite has been determined by spectroscopic method with Griss reagent. Nitrate has been reduced by Zn to nitrite then determined by spectroscopic method with Griss reagent. Ammonium has been determined by Nessler method.

3. RESULTS AND DISCUSSION

3.1. Validation of the analytical method

Before analysis of ballast samples, analytical methods have been validated to ensure the reliability of analytical results. For each analytical method, a calibration curve has been constructed, followed by the determination of LOD and LOQ values. Finally the precision of method has been assessed through percentage relative error E_r and the coefficient of variation (CV). Results are given in Table 2.

All calibration curves had relatively high relationship of linearity with the R^2 all larger than 0.99. LOD values calculated from calibration curves range from 0.008 to 0.110 ppm while LOQ values vary from 0.022 - 0.365 ppm. The low values of LOQ indicate that the method is very suitable for the determination of low concentrations of P, N in ballast water samples. The CV and error values were in the good range from 1% to 15% and to 0.1% to 8.1%.

Table 2: Validation of the analytical methods to determine P and N

	LOD (ppm)	LOQ (ppm)	Er (%)	CV
Phosphorus	0.008	0.022	1 ÷ 10	1.0 ÷ 8.1
Nitrate	0.063	0.212	2 ÷ 12	0.1 ÷ 0.2
Nitrite	0.008	0.026	2 ÷ 10	0.6 ÷ 2.8
Ammonium	0.110	0.365	3 ÷ 15	0.2 ÷ 1.2

3.2. Determination and assessment of total phosphorus (T-P) and total nitrogen (T-N) in ballast water

3.2.1. Determination of T-P

T-P values of 07 ballast water samples are presented in Fig.1. The total phosphorus ranges from 0.014 to 0.080 mg/L, among which the greatest concentration of P has been found in Hoàng Anh X sample (0.08 mg/L) and the lowest concentration in Hoàng Anh 1 sample. The mean T-P is 0.040 mg/l. According to ASEAN Marine Water Quality Criteria (AMWQC) [5] on estuarine water quality ([P] < 0.045), only 2 out of 7 samples (Hoàng Anh X and Hoàng Anh 3) have the amount of P exceeding the allowable limit (see Figure 1). However, when compared to Vietnam Standard (TCVN 5943) [6] on coastal water quality ([P] < 0.015 mg/L), Hoàng Anh 1 is the only one sample that has T-P within the allowable limit.

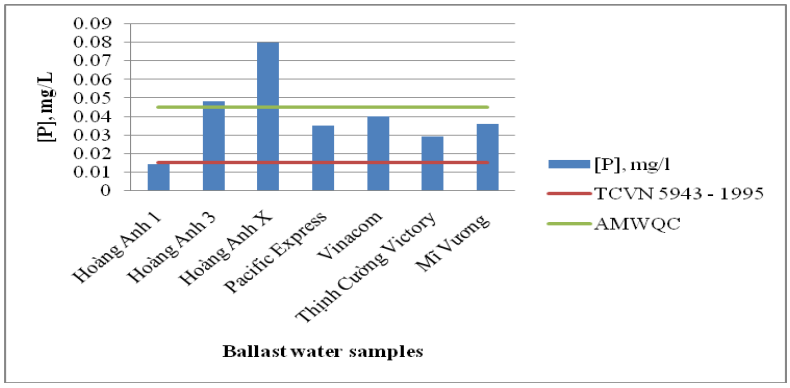

Figure 1: Total Phosphorus variation in ballast water samples

3.2.2. Determination of Nitrite

Results on nitrite concentration in ballast water samples are given in Fig.2. Nitrite concentrations range from 0.026 to 1.372 mg/L. All samples present lower amount of N- NO_2^- than AMWQC standard for marine water, except Mỹ Vương sample which has N- NO_2^- concentration 7.5 times higher than allowance level.

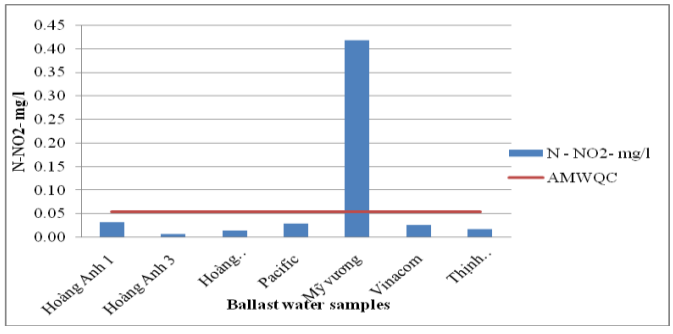

Figure 2: N- NO_2^- variation in ballast water samples

3.2.3. Determination of Nitrate

In Fig. 3 is presented the concentrations of nitrate in 07 ballast water samples. The nitrate concentrations range quite remarkably from 0.05 to 1.08 mg/L. The average amount of N-NO_3^- is 0.65 mg/L which is 10 times higher if compared with the allowance level by AMWQC. Most of those samples are higher from 6 to 20 times than allowance value of N-NO_3^- (0.06mg/L of AMWQC standard) except Hoàng Anh 3 sample.

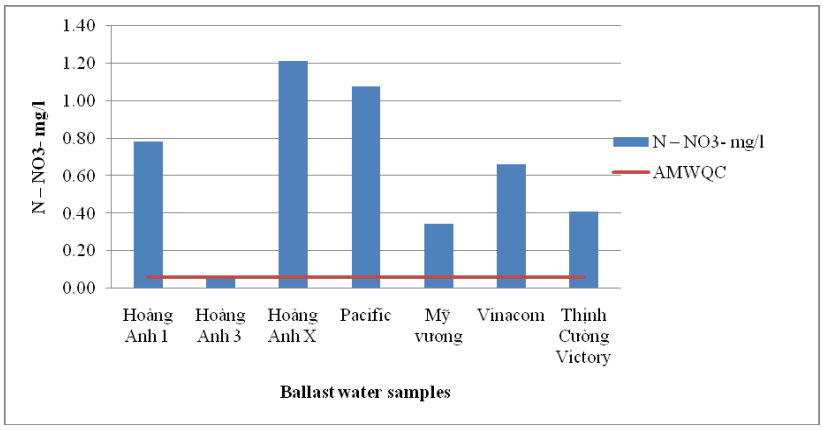

Figure 3: N- NO_3^- variation in ballast water samples

3.2.4. Determination of Ammonium

As can be seen in Fig.4 , the average N- NH_4^+ concentration is 0.049 ppm. Since this value is much lower if compared with other N-forms such as NO_3^- and NO_2^-, N tends to exist as other forms than NH_4^+. The concentrations of N- NH_4^+ lie far below the allowace value of 0.2 ppm provided by The US Environmental Protection Agency EPA [7].

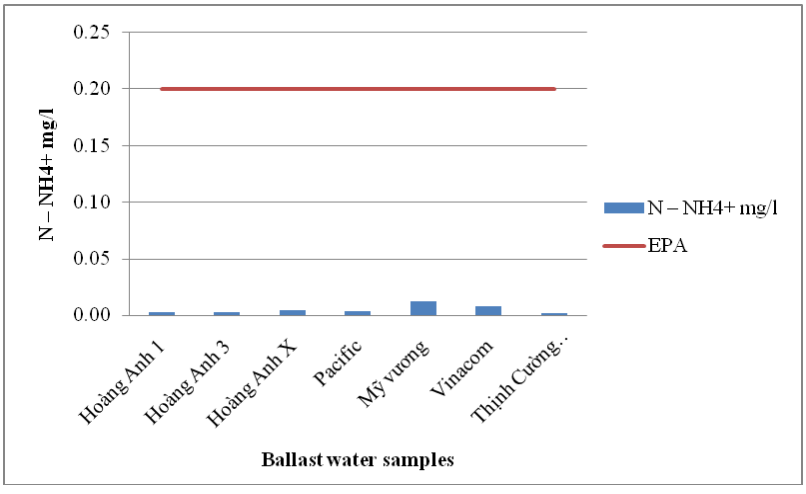

Figure 4: N- NH_4^+ variation in ballast water samples

3.2.5. Total N in ballast water

The total N concentrations are presented in Fig. 5, where total N ranges from 0.063 to 1.235 ppm. Among those samples, Hoàng Anh 3 has the smallest value which distinguishes it from other samples. The rest 6 samples have similar total N values in the range of 0.8 to 1.2 ppm (see Figure 5). In particular, the percentage of three type of Nitrogen increases from NH_4^+ to NO_3^-. It follows well the N cycle in nature

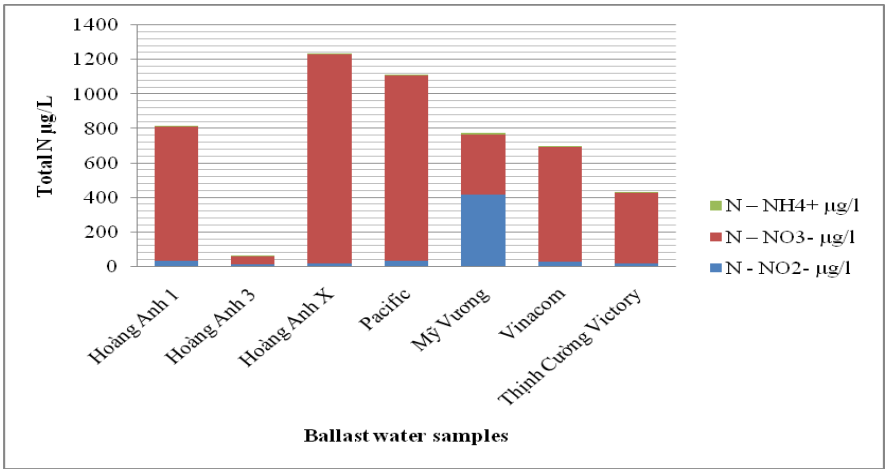

Figure 5: N- forms in ballast water samples

In conclusion, in general the nutrients of those samples are within allowance value. In particular, Hoàng Anh 3 is within the acceptable value in all three forms of N. In contrast, Hoàng Anh X may be an warning to the environment since both P and N ($N\text{-}NO_3^-$) value are above the allowance value.

4. CONCLUSIONS

The amount of nutrients including P and N in ballast water varied from ship to ship. Most of samples have total P and total N higher than ASEAN Marine Water Quality Criteria (AMWQC) on estuarine water quality but smaller than Vietnamese Standard (TCVN 5943) on coastal water quality. One sample (Hoàng Anh X) has high level of both T-P and T-N above the allowance level. This research provides primary results about several chemical characteristics of ballast water in cargo ships taken at Hải Phòng port. More analyses should be done to get an assessment on the current status of ballast water in Vietnam, which will be the basis of a proper and effective management of ballast water in Vietnamese sea transportation industry.

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