Effects of sea reclamation project on heavy metal concentrations in seawater- a case study in Qixingtu

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Abstract. Sea reclamation will pollute the environment and reduce the quality of marine water. In order to discuss the impact of reclamation on seawater, 4 heavy metals (Cu, Pb, Zn, Cd) in seawater near Qixingtu were analyzed for three time periods: 2007 (before the reclamation), 2016 (not long after the reclamation) and 2018 (after the reclamation). As a result, concentrations of all the 4 heavy metal met the standard requirements in surrounding seawater of Qixingtu, which indicated a good sea water quality in this area. Except for Cd, all the other heavy metals showed a trend of increasing first and then decreasing. Sea reclamation could indeed aggravate the heavy metal pollution in the surrounding seawater but the impact would recover through reasonable treatment and protection.

1. Introduction
Sea reclamation projects have created obvious economic value by expanding the available space of sea and land, alleviating the contradiction of population and land. They have effectively promoted the economic development [1-2]. However, the negative impact on ecological environment shouldn’t be underestimated. Large-scale land reclamation activities have produced a large number of pollutants, and caused changes in seawater quality [3-5].

Taking Qixingtu as an example, this paper analyzes the variation trend of heavy metal content in seawater before and after reclamation, to discuss the impact of reclamation on seawater quality.

2. Materials and method

2.1. study area
Qixingtu is located in the southwest of Meishan Island, Ningbo. The reclamation project of Qixingtu was started in 2008 and completed in July 2015. The change of remote sensing images before and after reclamation is shown in Figure 1.
2.2. Sample collection and analysis

Seawater samples were collected in the area around Qixingtu of three time periods (all in April): 2007 (before the reclamation), 2016 (not long after the reclamation) and 2018 (after the reclamation). The concentrations of 4 heavy metals (Cu, Pb, Zn, Cd) were determined in the laboratory by Atomic absorption spectrophotometry. All the measurements were made according to the Code for Marine Survey (GB/T 12763-2007) and the Code for Marine Monitoring (GB 17378-2007).

3. Results and discussion

3.1. Sea water quality in Qixingtu

According to the Marine Function Zoning of Zhejiang Province (2011-2020), marine environmental protection requirements in the study area are as follows: sea water quality should be carried out according to the second requirement of the Marine Water Quality Standard (GB 3097-1997). Heavy metal concentrations in Qixingtu (2018) and in other places, as well as the limiting value of the second class standard were listed in Table 1. In sea area around Qixingtu, these 4 heavy metal met the standard requirements in all the collecting samples. In addition, the concentrations of Pd and Cd was lower than those in other places, both of these indicated seawater around Qixingtu area had good sea water quality. In most of the places, seawater concentrations followed similar rank trends: Zn > Cu > Pb > Cd, respectively. Maritime transport may be a source of heavy metal contamination; boats made of alloy generally contain both Zn and Cu [11] (Zhou et al., 2007). These industrial materials can be released into the environment during production and through the use of metals and products containing them [7] (Zhang et al., 2015).

Table 1. Heavy metal concentrations in seawater in different sea area

| Study area                  | Reference                  | Cu   | Pb   | Zn   | Cd   |
|-----------------------------|----------------------------|------|------|------|------|
| Qixingtu(2018.4)            | This study                 | 1.55 | 0.18 | 11.82| 0.08 |
| Hainan                      | Hao et al., 2019 [6]       | 0.72 | 0.57 | 12.84| 0.12 |
| Zhoushan                    | Hao et al., 2019 [6]       | 1.50 | 0.68 | 10.65| 0.38 |
| West Guangdong              | Zhang et al., 2015 [7]     | 1.81 | 2.47 | 9.98 | 0.09 |
| Jiangsu                     | Yuan et al., 2005 [8]      | 3.55 | 22.74| 28.20| 1.15 |
| Southeast Coast of India    | Sankar et al., 2018 [9]    | 0.24 | 0.29 | 2.67 | 0.45 |
| Oman sea                    | Bazzi, 2014 [10]           | 3.22 | 2.08 | 9.76 | 0.16 |
3.2. Comparison of heavy metal concentrations for three period
The comparison of heavy metal concentrations for three period was listed in Table 2. As a result, the average concentrations of Cu were 1.36 μg/L, 2.18 μg/L and 1.55 μg/L in 2007, 2016 and 2018 respectively. The average concentrations of Pb were 0.58 μg/L, 0.64 μg/L and 0.18 μg/L in 2007, 2016 and 2018 respectively. The average concentrations of Zn were 10.92 μg/L, 16.45 μg/L and 11.82 μg/L in 2007, 2016 and 2018 respectively. The average concentrations of Cd were 0.12 μg/L, 0.05 μg/L and 0.08 μg/L in 2007, 2016 and 2018 respectively.

Table 2. Heavy metal concentrations in seawater of three periods

|       | Cu (μg/L) | Pb (μg/L) | Zn (μg/L) | Cd (μg/L) |
|-------|-----------|-----------|-----------|-----------|
|       | Average   | Maximum   | Average   | Maximum   | Average   | Maximum   | Average   |
| 2007.04 (n=13) | 1.36      | 1.95      | 0.58      | 0.83      | 10.92     | 12.70     | 0.12      |
| 2016.04 (n=20) | 2.18      | 2.58      | 0.64      | 0.84      | 16.45     | 22.90     | 0.05      |
| 2018.04 (n=20) | 1.55      | 3.50      | 0.18      | 0.44      | 11.82     | 33.00     | 0.08      |

3.3. Effects of reclamation project on heavy metal concentrations in seawater
In order to analysis the impact of reclamation on heavy metal concentrations in seawater, histogram plots in three time periods were drawn in Figure 2. It can be seen from the figure that except for Cd, all the other three heavy metals showed a trend of increasing first and then decreasing. That is, not long after the reclamation implemented, heavy metal contents were higher than those before the project, this demonstrated that the implementation of reclamation would indeed aggravate the heavy metal pollution in the surrounding seawater. However, after the reclamation, water quality tended to get better again through reasonable treatment and protection.
Conclusions

The concentrations of the 4 heavy metal met the standard requirements in surrounding seawater of Qixingtu, which indicated a good sea water quality in this area. Except for Cd, all the other three heavy metals showed a trend of increasing first and then decreasing. Reclamation would indeed aggravate the heavy metal pollution in the surrounding seawater but the impact will recover through reasonable treatment and protection.

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