

## Field Survey of Turbidity during Environmental Dredging

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**ABSTRACT:** To examine the turbidity diffusion suppression that occurs using the environmental dredging method, the generated turbidity accompanying waterway dredging was investigated. Five survey boats were arranged at intervals of 25 m centered on the front of a dredging boat. Turbidity was then measured at each location. Results show that highest turbidity occurs on the centerline of the dredging position. Averages of the suspended solids(SS) concentration converted from turbidity are 15.9 mg/L in the lowest layer, 4.6 to 9.4 mg/L from the lower layer to upper layer, and 1.2 mg/L in the upper layer. Based on these measurements, the generated amount of turbidity was 0.608 t/h. The standard unit of turbidity generation  $\omega_0$  becomes  $7.13 \times 10^{-3} \text{ t/m}^3$ . When compared with the standard unit of turbidity generation of an ordinary grab dredge measured in the past, the value for the environmental dredging method was almost the same as the minimum value for the ordinary grab dredge. When compared with the maximum value, the turbidity generation for the environmental dredging method was one-seventh the value of the ordinary grab.

### INTRODUCTION

Techniques for dredging sediments polluted by heavy metals and dioxins must create little pollution diffusion. They should remove only a polluted layer to limit the final disposal amount. Furthermore, they should produce high solids concentrations by taking in very little water to reduce the need for surplus water treatment at the disposal site. As a method meeting those needs, Cable Arm Inc. of the U.S.A. has developed an environmental dredging system (Y. Murota et al., 2004). This study investigated the turbidity generation amount produced by waterway dredging to verify the inhibitive effect of turbidity diffusion, which is one characteristic of the environmental dredging method.

## MATERIALS AND METHODS

The site examined was a channel dredging work site at Hiroshima port in Japan. The dredging area was  $75,000 \text{ m}^2$ , dredged soil volume of  $6,600 \text{ m}^3$ , and the final depth of the dredged surface was targeted to be  $-14.0 \text{ m}$  below water level. The soil property is clay. Fig. 1 shows dredging circumstances and Fig. 2 shows the  $7 \text{ m}^3$  Cable Arm environmental grab bucket that was used. Investigation results are summarized as a turbidity generation basic unit (Ministry of Land, Infrastructure, Transport and Tourism, Ports and Harbors Bureau, 2004). The turbidity generation basic unit is an index for estimating turbidity diffusion obtained by calculating the generation of turbidity using each dredging construction method.

To measure turbidity, five survey boats were located, centered on point c at the front of the dredging boat at intervals of  $25 \text{ m}$ . A measurement line of  $100 \text{ m}$  was set. Here, the arrangement of point a and point c, at either end of the investigation line, is set to be the same turbidity as the background. Layers of survey depths  $-1.0 \text{ m}$ ,  $-3.0 \text{ m}$ ,  $-6.0 \text{ m}$ ,  $-9.0 \text{ m}$ ,  $-12.0 \text{ m}$ , and  $-15.0 \text{ m}$  ( $-15.5 \text{ m}$ ) from the water surface were chosen respectively as turbidity measurement layers. Fig. 3 presents a plan arrangement of a turbidity measurement line. Fig. 4 shows a cross-section arrangement.



FIGURE 1. Conditions of waterway dredging by environmental dredging grab.



FIGURE 2. Shape of environmental dredging grab ( $7 \text{ m}^3$  class).

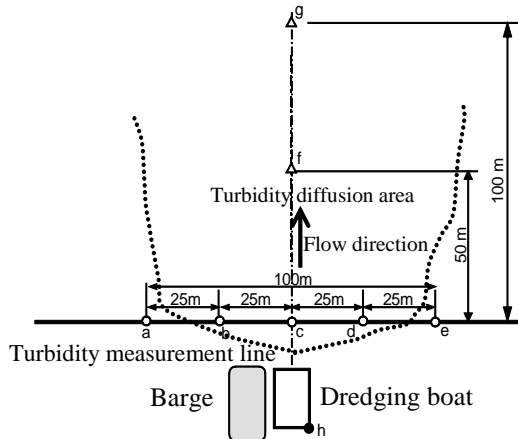


FIGURE 3. Plan arrangement of turbidity measurement line.

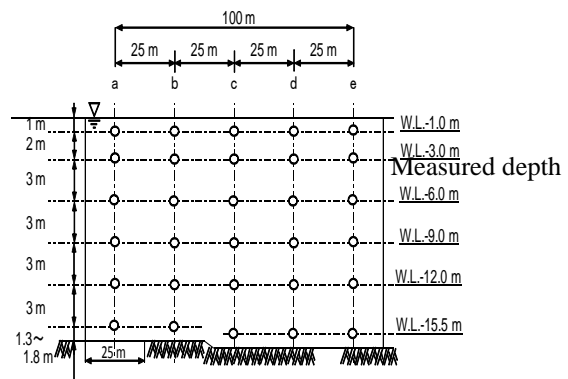


FIGURE 4. Cross-section arrangement of turbidity measurement line.

Flow direction and flow speed were measured on the dredging boat at an interval of 15 minutes. According to the instruction by radiowaves from the survey boat located at point c at intervals of 3–5 minutes, turbidity was measured 25 times in all, at each measurement point simultaneously. Results verified that the water flow direction at the site changes 180 deg from the time of high tide to the time of low tide. Therefore, the turbidity measuring time is defined as 2 hour to be the spring tide of the rising tide when the flow speed is fastest and the flow direction is in a specific direction. To check the dampening conditions of turbidity, water was sampled at point f, away from the dredging boat by 50 m, and at point g, by 100 m, and SS concentration was measured.

## RESULTS AND DISCUSSION

**SS concentration of the turbidity measurement line.** Table 1 shows average values of the SS concentration (converted from turbidity) in the turbidity measurement line generated by dredging. Values shown in the table are those obtained by subtracting background(BG) values from the SS concentration at each point, representing the effects of dredging only. Results show that turbidity is centered around point c in the vicinity of the dredging position and at point c the average SS concentrations are 15.9 mg/L in the lowest layer, 4.6–9.4 mg/L in from the lower layer to upper layer, and 1.2 mg/L in the upper layer. At points b and d, which are distant from the dredging position by 25 m, the SS concentration is as low as 0.0–1.6 mg/L. Points a and e are distant from the dredging position by 50 m; the SS concentration there shows low values of 0.0 to 1.4 mg/L as well. The measurement point at which the SS concentration becomes negative after subtracting BG is defined as Not Detected (ND). The turbidity generated by dredging can be said to almost pass between the set turbidity measurement lines at 100 m. It was verified that turbidity was attenuated and that it did not diffuse over a broad area such as 1.3 mg/L at point f, which is distant from the dredging boat by 50 m and 0.3 mg/L at point g, which is 100 m distant.

**TABLE 1. Results of SS concentration (average) of turbidity measurement line**

Measurement depth	Measurement results of SS concentration (average)				
	a	b	c	d	e
W.L.- 1.0m	0.1	0.6	1.2	0.5	0.2
W.L.- 3.0m	ND	ND	9.4	ND	ND
W.L.- 6.0m	ND	ND	5.7	ND	ND
W.L.- 9.0m	ND	ND	4.6	ND	ND
W.L.-12.0m	0.9	1.6	7.5	0.8	0.5
W.L.-15.0m	0.3	0.4	-	-	-
W.L.-15.5m	-	-	15.9	1.4	1.4

**Calculation of standard unit of turbidity generation.** Results of turbidity investigation show that the amount of turbidity generation and the standard unit of turbidity generation (Ministry of Land, Infrastructure, Transport and Tourism Ports and Harbors Bureau, 2004) are obtained using the following formulae.

Calculation formula of generated turbidity amount

$$W_o = S \times B \times H \times u \times 10^{-6} \quad (1)$$

$W_o$ : Turbidity generation amount (t/h)

$S$ : Average SS concentration with BG value passing through the measurement line being subtracted (mg/L)

$B$ : Turbidity region width on the measurement line (m)

$H$ : Water depth (m)

$U$ : Flow speed (m/h)

Calculation formula of the standard unit of turbidity generation

$$\omega_{01} = W_o / Q_o \quad (2)$$

$\omega_{01}$ : Standard unit of turbidity generation at the measurement line position (t/m<sup>3</sup>)

$Q_o$ : Handled sediment volume (m<sup>3</sup>/h)

The standard unit of turbidity generation changes significantly according to the flow speed and soil property of the site even if the dredging method and handled sediment volume are the same. Therefore, it is standardized by the following formula using the particle size of  $d = 74$  micrometers, which is the boundary between the sand and the silt or smaller, and turbidity limit flow speed  $u = 7$  cm/s corresponding to the 74 micrometer particle size.

Standardization formula of standard unit of turbidity generation

$$\omega_o = (R_{74} / R_{01}) \times \omega_{01} \quad (3)$$

$\omega_o$ : Standardized standard unit of turbidity generation (t/m<sup>3</sup>)

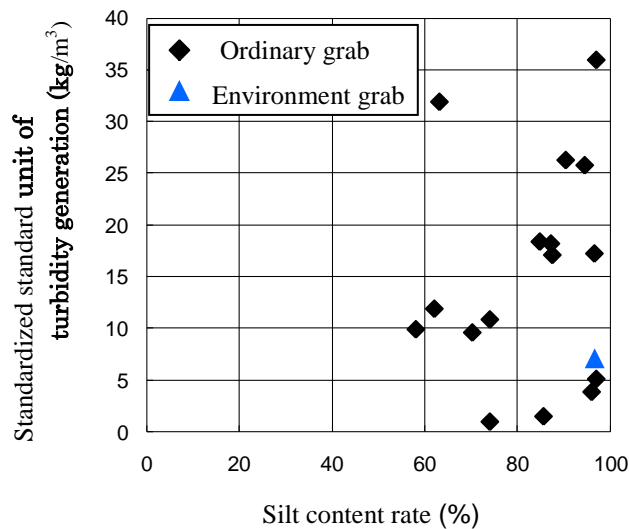
$\omega_{01}$ : Standard unit of turbidity generation obtained under the site flow conditions

$R_{74}$ : Grain size accumulation percentage of 74 micron or less of handled soil (%)

$R_{01}$ : Grain size accumulation percentage of grain size or less corresponding to the site flow speed (%)

Based on (1), (2), and (3) above, turbidity generation amount is 0.608 t/h. The standard unit of turbidity generation  $\omega_0$  is  $7.13 \times 10^{-3} \text{ t/m}^3$ .

The Ministry of Land, Infrastructure, Transport and Tourism Ports and Harbors Bureau in Japan coordinates the gathering of data on the standard unit of turbidity generation of ordinary grab dredging. The present investigation results are shown in Fig. 5 with data on the standard unit of turbidity generation (only for fine-grained soil) of grab dredging carried in a guidebook on the prediction of influence of turbidity in the port construction work (The Ministry of Land, Infrastructure, Transport and Tourism Ports and Harbors Bureau, 2004). The generation standard unit of the environmental dredging method obtained in the present experiment is positioned as the smallest value compared to an ordinary grab dredge when silt content was 95% or larger. When compared with the maximum value for ordinary grab dredge, the environmental dredging technique releases one-seventh the amount of sediment. From the above, it is verified that the environmental dredging method is a technique having low turbidity generation rates.



**FIGURE 5. Standard unit of turbidity generation of environmental grab dredging and ordinary grab dredging.**

## CONCLUSIONS

In this study, to verify the suppression effect on turbidity of the environmental dredging method, turbidity generation produced by waterway dredging was surveyed. Results showed the turbidity generation amount to be 0.608 t/h for study conditions. The standard unit of turbidity generation  $\omega_0$  as an index for predicting turbidity diffusion is

$7.13 \times 10^{-3} \text{ t/m}^3$ . When compared with the standard unit of turbidity generation for an ordinary grab dredge measured in the past, it is almost the same as the smallest value and about one-seventh of the largest value. From the above, results show that the environmental dredging method examined is a technique that causes little turbidity diffusion when compared to ordinary dredging methods.

## **REFERENCES**

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- Murota, Y., Y. Kurumada, and N. Moriya. 2004. "Dredging techniques for contaminated sediment." *WODCON, XVII* : C1-3 pp.1-14.