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Employing Response Surface Methodology for optimization of slow release Biostimulant ball in contaminated coastal sediments in Busan, South Korea

† *Young-Chae Song · Bakthacachallam Subha · Jung Hui Woo**

† *Department of Environmental Engineering division, Korea Maritime and ocean university, Busan, Korea*
**Nuclear Power Equipment Research Center, Korea Maritime and Ocean university, Busan, Korea*

Abstract: *The Coastal sediment is highly contaminated due to ship transportation, industries discharges and urban sources. Various contaminants release into seawater and settle in marine sediment and it significantly affect marine eco system. In the present study evaluated the optimization of slow release biostimulant ball (BSB) in coastal sediment in busan. The effective variables like BSB size, distance and month variables on VS reduction was determined by using Response surface methodology(RSM). The analysis of variance (ANOVA) and coefficient determination (R2) of VS was 0.9369 and maximum reduction of VS was obtained in 3cm ball size and 5.5cm distance and 4 month interval time. This result revealed that the BSB in effective VS reduction in coastal sediment.*

Key words :*Coastal sediment, Biostimulant ball, Response surface methodology, VS reduction*

1. Introduction

Pollutants in the marine sediments can spread to the surrounding seawater and affecting benthic microorganism. The marine pollution includes a range of threads including from land based sources, oil spills, untreated sewage, heavy metals pollutants etc (McCook 1999, Bellwood et al., 2004). Therefore, most of the researchers found that an effective techniques used to treat contaminated coastal sediment, but there were some disadvantages was occur. Slow release biostimulant ball is an effective considerable attention because of its good efficiency and environmentally friendly nature. The aim of present study is investigated the employing RSM for optimization of BSB in contaminated coastal sediment in Busan, South korea.

2. Materials and Methods

2.1 Methodology

The sediment was collected from Busan Northport and characterized according to standard method (APHA, 1998)(Table 1). A three level factorial design was obtained by Design Expert software 9.0.3. RSM is a statistical tool for exploring relationship between response variable and Table.

Table 1. Physicochemical parameter of Busan Northport design variable (Thakur et al., 2009).

Parameters	Busan Northport
Sand (%)	14.3
Silt (%)	18.6
Clay (%)	67.1
pH (at 25°C)	7.56
COD_{mn} (g/Kg)	28.4
Water content (%)	49
TS (%)	51.33
VS (%)	11.06
AVS(mg S/Kg)	246

Central Composite Design (CCD) under RSM was employed with three selected variable like BSB size (X1), BSB distance (X2) and month interval (X3) were selected for analysis of VS. The system explained by second degree quadratic polynomial equation

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_{11}X_1^2 + B_{22}X_2^2 + B_{33}X_3^2 + B_{12}X_1X_2 + B_{13}X_1X_3 + B_{23}X_2X_3$$

where, Y was predicted response, X1, X2, X3 were input variables are coded as -1.682, 0, 1.682 (Table 2)

† Corresponding author: soyc@kmou.ac.kr

Table 2. Process variables and levels

Variables	Factors	Levels				
	X	-1.682	-1	0	+1	+1.682
Biostimulant ball size	X_1	1	1.75	3	4.25	5
Biostimulant ball distance	X_2	1	2.8	5.5	8.2	10
Time (month)	X_3	0	1.5	3	4.5	6

2.2 Experimental Procedure

For BSB preparation, 1 kg uncontaminated sediment mixed with 0.5M sulfate, 1M nitrate and 0.5M acetate and then dried it for room temperature. The BSB size and distance were prepared based on RSM model. After making the BSB and dried it at 60°C for 48 hrs, then the dried ball were coated with polymer solution of polysulfone (10 wt%).

3. Results and Discussion

3.1. Fitting second order polynomial equation

Table 3 explained the full factorial design of the experiments and the relationship between actual and predicted value of Y. The interaction of the factor with p value less than 0.05 is considered as significant value of Y (Segurola et al., 1999). The final equation (2) obtained in coded factor of VS

$$pH\ (Y_1)=55.71+0.89X_1+0.36X_2+19.13X_3-4.62X_1^2-5.19X_2^2-2.95X_3^2-5.74X_1X_2-1.78X_1X_3+1.28X_2X_3 \quad (2)$$

Table 3. Full factorial design

Run order	Biostimulant ball size (X_1)	Biostimulant ball distance (X_2)	Month (X_3)	VS reduction (%)	
				Exp value (%)	Pre value (%)
1	3	5.5	3	55.17	55.71
2	4.25	2.8	1	29.31	33.15
3	1.75	2.8	1	3.45	16.33
4	4.25	8.2	3	58.10	57.10
5	3	1	2	45.43	40.43
6	3	5.5	2	55.26	55.71
7	3	10	2	53.45	41.65
8	1.75	8.2	1	18.45	25.98
9	4.25	8.2	1	4.91	19.83
10	3	5.5	2	55.26	55.71
11	3	5.5	2	55.26	55.71
12	4.25	2.8	3	60.95	65.30
13	1	5.5	2	50.52	41.14
14	3	5.5	0	32.76	15.20
15	3	5.5	4	78.79	79.55
16	3	5.5	2	55.17	55.71
17	1.75	2.8	3	58.62	55.59
18	5	5.5	2	51.55	44.13
19	3	5.5	2	55.26	55.71
20	1.75	8.2	3	62.33	70.36

The statistical significance of the ratio of mean square variation due to regression and mean square residual error was tested using ANOVA. The associated p value is used to estimated whether F is large enough to indicate significant. The model R^2 value of 0.9369 and the value are high, high corelation between observed and predicted value. The ANOVA thus proves that form of the model was chosen to explain the relationship between the factor and the response is correct. Figure 1a and Figure 1b explained the BSB size has significantly interact with distance which is an evident from the elliptical nature in the 3D image. Figure 1a and Figure 1c variables of size and month effect on VS reduction of coastal sediment. The result showed maximum reduction was observed in 3cm ball size, 5.5cm distance with 4month interval. This result revealed that BSB is effect for VS reduction in contaminated coastal sediment.

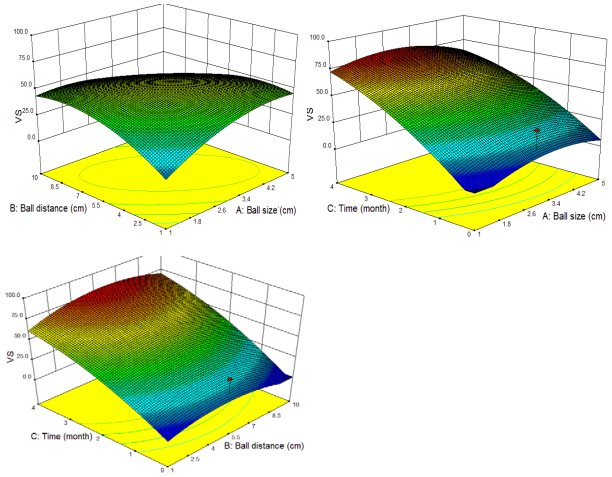

Figure 1. Three dimensional surface plot of VS reduction (a) BSB ball size distance (b) size and month c) distance and month interval.

This result indicate that the biologically and biochemically mediated processes in the sediment are the utmost importance to ecosystem and microbes present the sediment play a vital role and driving force behind of many process which are utilizing the nutrients in the slow release biostimulant ball and reduce VS.

4. Conclusion

RSM is an experimental design applied in this study to optimize the BSB size, distance and month interval. The result concluded that BSB with 3cm size, 5.5cm distance and last term of 4 month interval were effective for reduce VS up to 80% in contaminated coastal sediment.

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