ESTIMATION OF MASS BALANCE AND THE BEHAVIOR OF PCDD/DFs IN NAKDONG RIVER ESTUARY REGIONS

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Introduction

Persistent Organic Pollutants (POPs) are discharged from many sources into the environment, then carried through the atmosphere and water-bodies and deposited both in the air and water. In this way, they are repeatedly circulated within the sea and exchanged from the air to the sea and vice versa[1].

Recently, researches on mass balance in the estuary regions has been conducted by many scientists including S. Smith (1996), G. Wattayakorn (1997), J. Hollibaugh (1997), C. Isebor(1998). However, in these previous studies, when much inflow load is flooded, their diffusion and behavior in the sea are investigated clearly[2,3,4]. This study measures inflow load into the sea quantitatively and calculates mass balance as basic research for the quantitative assessment of its route prediction within the oceanic water-body as well as residual and deposition effects.

Therefore, the inflow load of PCDD/DFs within the Nakdong River estuary in Korea is calculated and through interpretation of its behavior in the estuary region, mass balance is estimated.

Materials and Method

Section Setting

In this research, on the basis of the sea-water mobile model (Lee 2002; Yun 2004), an experiment estimating the sectional discharge flux of sea-water circulation is conducted as it is considered as one of the physical factors affecting the behavior of endocrine disruptors that flow to and fro between sand bars in the Nakdong River estuary regions[7].

The Nakdong River estuary area is set up as seven internal boxes and five external boundary boxes as shown in Fig 1. The seven internal boxes are divided for the purpose of grasping efficiently the interactive functions of the sectional discharge flux by sea-water circulation. Moreover, the sectional discharge flux is calculated through the discharge flux in each section.

Also, in the external boxes, numbers 9 and 10 in the figure are established as boundaries of fresh water inflow from the land and number 8 as a border of inflow and outflow from the New Port Construction Area.

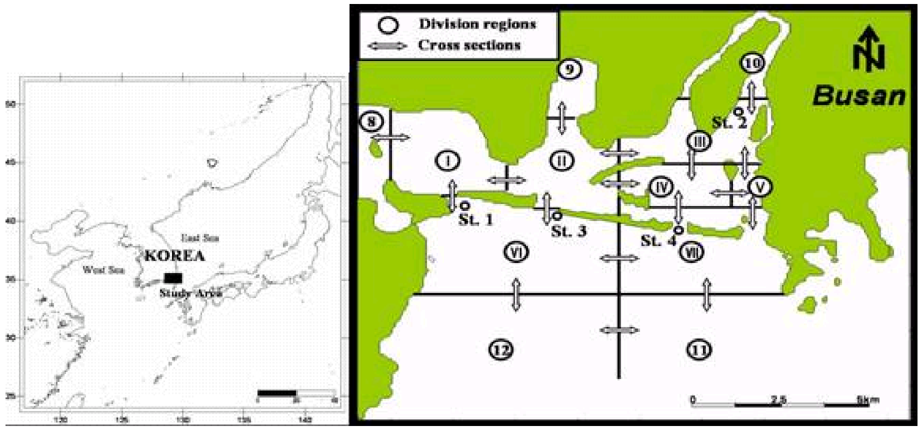

Figure 1. The Subject Regions and Sections Settings.

Balance Interpretation of PCDD/DFs

In order to calculate PCDD/DFs balance both in flood and drought seasons in the Nakdong River estuary regions, spheres 1 - 7 in Fig 1 are set up as one box model. The constituents of the mass balance are as follows:

△TCP (Total Concentration Pollutions) = TCPload - TCPout-j + TCPin-j - TCPout-o + TCPin-o = TCPss + TCPre + TCP

Here, △TCP indicates the residual amount of △Total (PCDD/DFs) in the estuary area. On the right side of the formula, the inflow load amounts of PCDD/DFs into the Nakdong River estuary area are shown (TCPload), the inflow and outflow load amounts to and from Jinhae Bay located to the west of the Nakdong River estuary area (TCPout-j, TCPin-j), and the inflow and outflow load amounts in the direction of the open sea from the Nakdong River estuary area (TCPout-o, TCPin-o): therefore, △TCP is calculated with the total amount of PCDD/DFs remaining in the Nakdong River estuary area[7,9].

The amount of PCDD/DFs accumulated within the estuary regions is calculated after being divided into the amount of PCDD/DFs sinking from the water layer to the sea-bottom (TCPss), the amount resurfacing from the sea-bottom (TCPre) and the amount of PCDD/DFs remaining in the sea-water.

Fore the PCDD/DFs concentration in the estuary regions, the average concentration of PCDD/DFs is shown in Table 1[6]. In order to estimate mass balance, the results expressed in Table 2 and 3 of the suspended load and bed load collection experiment are used for sinking and resurfacing amounts of PCDD/DFs.

Table 1. PCDDs/DFs concentration at each inflow point

Division	A	B	C	D	Out sea
PCDDs/DFs	0.40	0.77	0.77	0.57	0.17

Table 2. Experimental Results of Suspended Load Collection

St.	Dry-weight (g)	Sedimentation rate (g/ /day)	concentration Total PCDD/DFs (pgWHO-TEQ/g)	velocity Total PCDD/DFs (pgWHO-TEQ/ /day)
1	349.40	0.4562	0.150	0.068
2	0.28	0.0004	-	-
3	361.21	0.4720	0.047	0.022
4	57.10	0.0746	0.275	0.021

Table 3. Experimental Results of Bed Load Collection

St.	Direction	Dry-weight (g)	Bed load flux (g/ /day)	concentration Total PCDDs/DFs (pgWHO-TEQ/g)	velocity Total PCDDs/DFs (pgWHO-TEQ/ /day)
1	Northward	13.20	0.0675	0.128	0.009
	Eastward	114.96	0.5875		0.075
	Southward	37.13	0.1897		0.024
	Westward	98.84	0.5051		0.065
2	Northward	0.09	0.0005	-	-
	Eastward	0.38	0.0019		-
	Southward	2.78	0.0139		-
	Westward	1.55	0.0078		-
3	Northward	17.27	0.0878	0.134	0.012
	Eastward	-	-		-
	Southward	-	-		-
	Westward	345.96	1.7579		0.236
4	Northward	-	-	0.158	-
	Eastward	88.63	0.4219		0.067
	Southward	93.03	0.4703		0.074
	Westward	69.84	0.3524		0.056

Results and Discussion

Results of the Sectional Discharge Flux Calculation

The sectional discharge flux calculation is conducted based on the results of sea-water circulation. Fig 2 shows the calculated results of the discharge flux in each box and for each section.

Examining the calculated results of the main flow path of the discharge flux, the discharge into the open sea through Boxes 3, 4 and 7 were verified, however the main flow route in Boxes1, 2, and 6 reveal differences in Case-1 and Case-3.

Considering the accumulation density of the discharge flux per Box, in Case-1, only Box 6 shows positive figures, and negative figures are calculated in order of size from Boxes 7 to 5 and 6.

In consideration of these findings, when the flooded river effluence occurs, the discharge flux is observed to be accumulated in the sand bar area. Now, in the estuary regions of 4, 5, and 7 where the most active deposition of the sand bar is going on, the density is highest. In addition, when there is no stream flow or average daily stream discharge, the accumulation density range of the discharge flux is high in region 6. Consequently, the deposition of PCDD/DFs will be high in region 6.

Calculated Results of Mass Balance

After calculating the mass balance in the estuary regions, it is estimated that in flood season, of the total PCDD/DFs flowing in from all the streams (1,614,385 WHO-TEQ/day), approximately 35% is discharged to external gources. So, the residual amount in the estuary regions is calculated as 1,008,957 WHO-TEQ/day. Also, of PCDD/DFs remaining in the estuary area in flood season, the sinking and resurfacing amount is about 5% compared to the total residual amount.

In the drought season, the amount of PCDD/DFs flowing in from the streams is calculated as 92,691 WHO-TEQ/day and the amount flowing out is about three times more than that, 273,971 pg WHO- TEQ/day. Thus the accumulated PCDD/DFs of 271,074 pg WHO- TEQ/day is estimated to be discharged to the estuary area.

By taking all of these results into consideration, of the external discharge amounts of PCDD/DFs at each discharge point, over 99% flows into the open sea, but the amount flowing into Jinhae Bay is extremely low. The amount of PCDD/DFs flowing into the estuary area from the streams in flood season is 17 times higher than that in the drought season.

Acknowledgements

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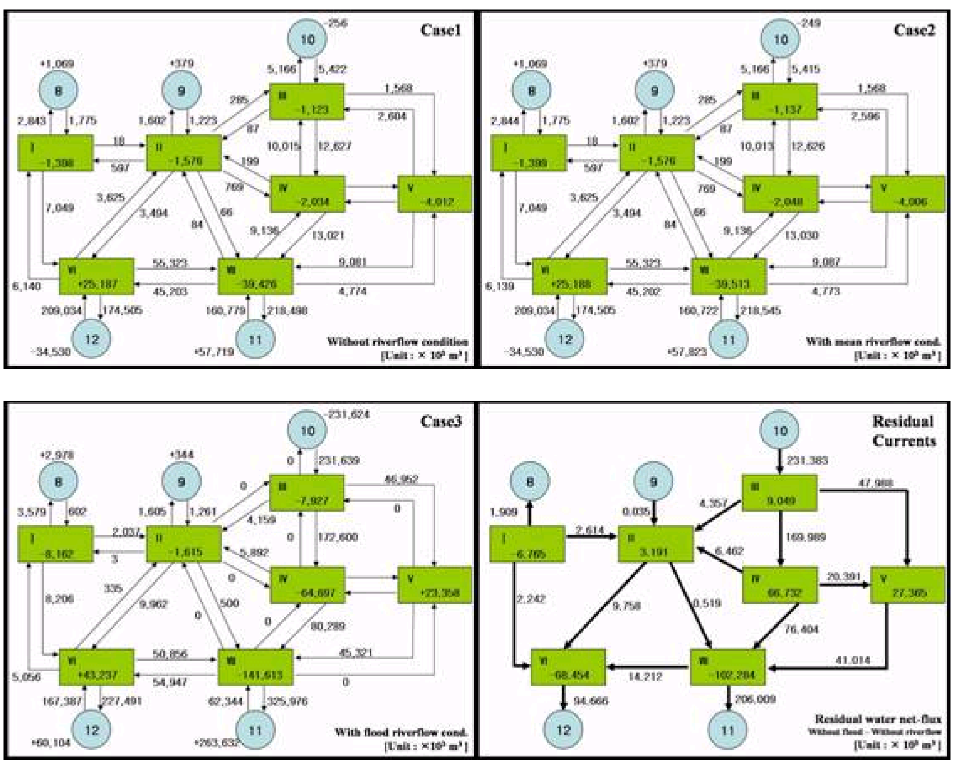

Figure 2. Movement Directions of Net-flux and Calculated Results of the Accumulation Density.

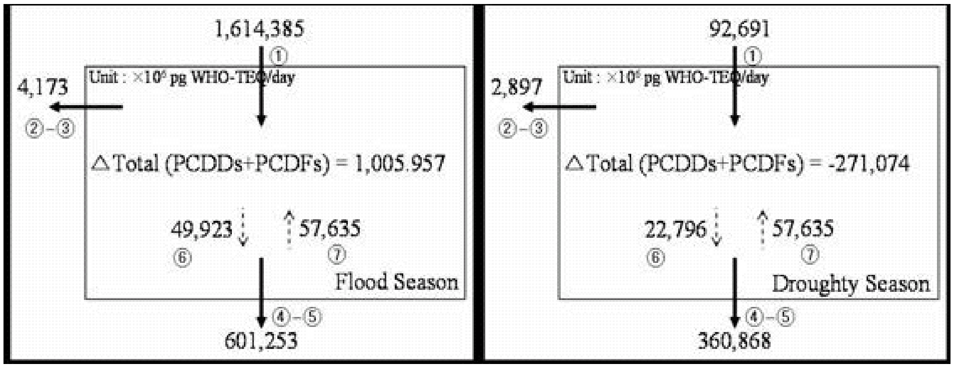

Figure 3. Calculated Results of Mass Balance of Total PCDD/DFs.