Comparison of Reservoir Sediment in Kum River Basin

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Abstract

This study was performed to survey the general feature of reservoir sediment in Daecheong, Sapkyo and Kumkang reservoir. For investigations, sediments were sampled at four sites in Dae-Cheongand two sites in SapKyo and Kumkang in June and October. The items for investigation are as follows; water content, loss on ignition(IG), porosity of sediment, contents of element such as hydrogen, nitrogen, carbon, phosphorus contents and nutrient release rates. Loss on ignition was measured to determine the contents of organic substance. And its ranges were determined 2.4~16.2% in Daecheong reservoir, 5.6~27.9% in Sapkyo and 4.8~18.7% in Kumkang reservoir. And, total phosphorus contents in sediments were measured 677~5,238㎍/g in Daecheong, 780~1,417㎍/g in Sapkyo and 604~1,452㎍/g in Kumkang reservoir.And release rates of nutrients were calculated 0.05~8.63mgP/m^2day and 4.99~36.56mgN/m^2day in Daecheong, 1.83×10^{-3}~3.23×10^{-2}mgP/m^2day and 1.97~3.22mgN/m^2day in Sapkyo, 8.31×10^{-3}~6.51×10^{-2}mgP/m^2day and 0.89~4.42mgN/m^2day in Kumkang reservoir, respectively. And this study attemped to determine the humus level of sediments. As a result of elemental analysis, C/N ratio was determined 3.0~13.1 in Daecheong reservoir, 6.5~13.0 in Sapkyo and 3.6~12.6 in Kumkang reservoir, respectively. From the elemental analysis, humus levels of reservoirs were changed from mesohumic to oligohumic state in all reservoirs.

keywords : reservoir sediment, humus level, interstitial water, overlying water,release rate, nitrogen release, phosphorus release

I. Introduction

Lake sediments can be regarded as a bank of a environmental information. Most natural and anthropogenic activities in a lake and its drainage area will, directly or indirectly, leave an imprint in the sediments.Consequently, lake sediments are of interest in many limnological studies and as well as in ecotoxicology and in aquatic pollution control programs. Welch[1] said that sediment data were used to indicate trophic changes. And he said that lake sediments are the product of lake life. Therefore, sediments reflect the lake type. Generally, lake can be classified according to several principles, e. g. based on their genetic geological origin, trophic level and thermal regimes. Sediments can also be distinguished by many premises: from genetic and geological viewpoints, geochemical considerations and according to numerous descriptive approches from sediment characteristics like color, texture, structure, grainsize, organic contents, algal contents or benthic community. The studies of correlations between sediments type and lake sourroundings were done during the 1930s and 1940s. So, many aspects of researches were established by Huchison[2], Thienemann[3], and Rodhe[4]. The trophic level of a lake can be expressed in terms of several or more or less interrelated measurements, e. g. primary productivity, water transparency, chlorophyll-a, algal volume, concentration of nutrients(N, P) and types of community of fish and bottom fauna. These individual means of expressing trophic level only tell us part of the entire "trophic level of reservoir" and "sediments types". Many researchers attemped to make clear the relations between water quality and environments of reservoir sediment. For example, many limnologists did their best to correlate the humus level and element compositions.

Generally, the element compositions of humic substances varies roughly accordingly(Gjessing, 1975[5]; Golterman, 1975[6]):C; 45-60%, O; 30-40%, H; 3-5%, N; 3-5%, P: 0.5%. This gives a C/N ratios for humus in the range of 10-20, which is significantly higher than that of plankton. Thus, the C/N ratio of lake sediments may be used as a criterion to distinguish humosity of lakes(Hansen, 1961[7]). Hansen presupposed that the sediments contained the three major components such as; organic matter, which can be expressed in a simple but crude way by the loss on ignition, the minerogenic matter and the inorganic biogenic matter, which is made up of the diatom frustles and biogenic precipitated calcium carbonates. From theses premises, Hansen uesd the difference in minerogenic matter and inorganic biogenic matter as a measure of a level of oligotrophy to eutrophy. And he also used the C/N ratio as a rough measure of humosity; polyhumic lakes should have a C/N ratio larger than 15 ; oligohumic lakes should have C/N ratios lower than 10.

We selected the reservoirs located in middle of our country; Daecheong, Sapkyo and Kumkang reservoirs. This study compared humus levels of Daecheong, Sapkyo and Kumkang reservoir sediments. In addition to analyse the humus levels of sediments,we wanted to analyse the changes of nutrients release rates between the 1st sampling period and the 2nd one.

Therefore, firstly, we could attempt to deduce the humus levels of reservoir sediment, based on the Hansen' s and Hakanson' s theory[8]. We analyzed the content of elements such as; hydrogen, carbon,

Table 1. Hydrological characteristics of Daecheong, Sapkyo and Kumkang reservoir

nitrogen andsulfur. And then, we could make an effort to attain the nutrient release rates from bottom sediments. So, we tried out to calculate the nutrient release rates using the Fick' s diffusion law[9]. And also, to compare the phosphorus release rate and phosphorus content in sediment, phosphorus content of sediment were determined. Total phosphorus content was determined by the ignition method of Anderson[10](Anderson, 1975).

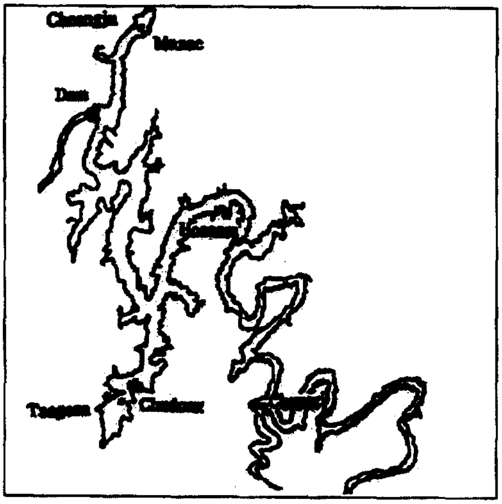

Fig. 1. The sediment sampling sites in Daecheong reservoir.

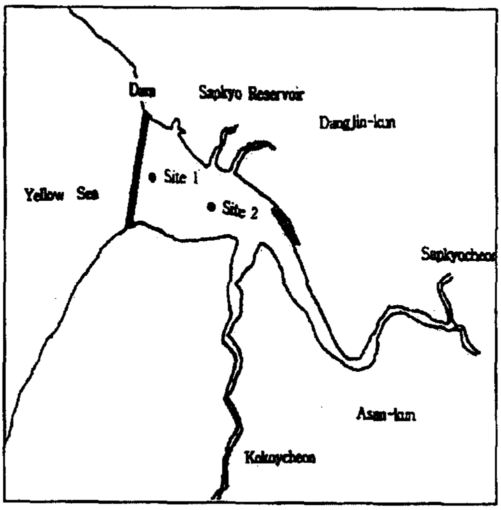

Fig. 2. The sediment sampling sites in Sapkyo reservoir.

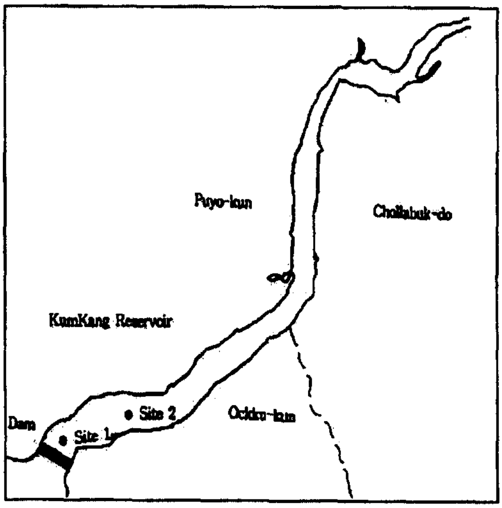

Fig. 3. The sediment sampling sites in Kumkang reservoir.

Ⅱ. Experiment Method

Sampling periods were choosen to compare the release rate difference between summer when the water temperature is being elevated and autumn when the water temperature is being lowered. The first samplings were done at June 16 and June 20 and the second sampings were done at October 15 to October 20. And the sampling sites were selected for comparing the regional characteristics of reservoir. So we could select 4 sampling sites in Dae-Cheong such as; fish farms in Hoenam, embayment in Chudong and Chusori, and the main stream in Munee, and we could select the 2 sampling sites in Sapkyo(Sapkyo 1, Sapkyo 2) and Kumkang (Kumkang 1, Kumkang 2), respectively.Instrument for the sampling was used Core Sampler made by Wild Co. in U.S. of which column dimension is 4.8cm(i.d.) × 50cm(L.). And the sample columns were carried to a laboratory and the experiments were done immediately. But the measurements were difficult to proceed instantly, the samples were frozen.

1. Water Content, Ignition Loss and Porosity

One column of sample was cutted by 0~2 cm and top layer was centrifuged to take out interstitial water 30min at 3,000rpm[11].The samples which was centrifuged were dried at 105~110℃ until the weight loss is constant. Water contents were calculated from the weight loss after cooling the dried sediment to the room temperature in desiccator. And, Loss on ignitions were determined by measuring the weight loss after igniting the dried sediment (ca. 10g) at 550℃ for 1 hours in electric furnace. And, Porosities of sediment were calculated the pore volume divided by the total volume of the sediment. The pore volumes were estimated by using the water content. And the total volume of the sediment was the sum of the water volume determined from the water content and the volume of dried sediment.

2. Determination of Phosphorus Content

Total phosphorus content(TP) in sediment was determined by the ignition method of Anderson' s. Determination of total phosphorus in soil, sediment or biogenic matter involves a preliminary digestion to convert the phosphorus into orthophosphate. Comparative studies of different methods for determination of total phosphorus in sediment have been made by Sommers[12]. Digestion with pherchloric acid is the most common and generally accepted procedure.

Determination of total phosphorus in lake sediment was done by ignition of sample in a muffle furnace at 550℃, boiling of the residue from ignition in 1N HCl. And subsequent determination of orthophosphate gave approximately the same valus as the pherchloric acid digestion.So we could determine total phosphorus content and inorganic phosphorus of sediment such as follow steps; Dried sediment or plant material was ignited in a muffle furnace in a porcelain(550℃ for 1h). After cooling the residue was washed into a 100ml erlenmeyer flask with 25ml 1n HCl and bolied for 30min on a hot plate. And then the sample was diluted to 50ml in a volumetric flask, and orthophosphate was determined.And for the determination oftotal inorganic phophorus(IP), it was extracted by 1N HCl for 16h at room temperature and then the concentration of phosphorus in extract was analyzed.And total organic phosphorus(OP) was determined by substracting the value of IP from that of TP[13]. For the determination of fractionate of IP, we used the method proposed by Chang and Jackson[14]. In this method, three fractions of phosphorus extracted by NH_4Cl, NH_4F, NaOH and H_2SO_4 were defined as aluminum bound phophorus(Al-P), iron-bound phosphorus (Fe-P), calcium-bound phosphorus(Ca-P), respectively.

3. Nutrients Release Rates

To determine the nutrients concentration in interstitial water, columns of sediment samples were cut by 0~2 cm and top layers of each columns were centrifuged to gain interstitial water at 3000 rpm for 30 minutes. The interstitial water obtained was filtered through 0.5m membrane filter and was diluted to an adequate concentration for the analysis. And, nutrients release rates from the sediment were calculated using the method based upon Fick' s diffusion law, which is

$R = \Phi \cdot Dt(Ci - Cw)/\Delta L$ ·································· (1)

where

Φ : porosity of the sediment

Dt : diffusion coefficient (㎡/day) of a nutrient at t℃

Ci : concentration (㎎/㎥) of a nutrient in the interstitial water of the surface sediment

Cw : concentration (㎎/㎥) of a nutrient in the overlying water

ΔL : difference of depth of the sediment sample (m).

As can be seen in the above equation, the release rate is proportional to the diffusion coefficient of a nutrient which depends on the kinds of nutrients, the porosity of the sediment, and the physical or biological turbulences on the sediment. The diffusion coefficients determined by many researchers are used to calculate the effective dispersion coefficient.

$D = Do \cdot \Phi^2$ ··· (2)

D : effective dispersion coefficient (㎡/d)

Do : molecular diffusion coefficient(㎡/d) when $\Phi=1$

The molecular diffusion coefficients of NH_4-N and PO_4-P used in this study are 8.5×10^{-5}㎡/day and 5.3×10^{-5}㎡/day, respectively. Diffusion coefficient is corrected as in the equation (3) since it depends on temperature.

$Dt = D \cdot (1 + a \cdot t)$ ··· (3)

Dt : diffusion coefficient(㎡/day) at t℃

a : temperature correction coefficient (1/℃)

t : temperature (℃)

In this study, 0.04 for the value of 'a' was used for NH_4-N and PO_4-P.

4. Determination of Element Content

Carbon, nitrogen and hydrogen contents of the dried sediments were measured using elemental analyser. Generally, major principle of elemental analyzer is dynamic combustion method like that; the sample weighted in tin capsule and placed in autosampler is dropped into a quartz tube kept at 1000 ℃ and with helium continuously flowingthere through. At start up carrier gas is enriched with a known quantity of oxygen and the sample is dropped into the tube a few moments before oxygen arrives, thus a violent exothermic reaction occurs. The gas mixture developed by oxidation passes on the catalytic layer present in the quartztube. Gas passed catalytic layer is transferred into the gas chromatic column and then each single components are separated.

Ⅲ. Result and Discussion

1. General Features of Sediment

The depth of water at the sampling sites could be an important factor which affects water temperature and the stratification phenomenon, it thereby makes a major role in the nutrient release from sediments. Depth of water, depth of sediment at sampling sites, water content, loss on ignition and porosity of surface sediments were shown in Table 2. The depths of sediment were 11.0~27.0cm in Daecheong, 14~34cm in Sapkyo and 7~32cm in Kumkang. The water contents were determined in 42~ 70% in Daecheong, 27~63% in Sapkyo and 23~66% in Kumkang and the porosities were determined in 62.1~84.6% in Daecheong, 55.8~82.6% in Sapkyo and 23~88.4% in Kumkang, respectively. Generally, Loss on ignitions were used to estimated organic contents of soil and sediment. In this study, we calculated the loss on ignitions by using the difference of weight after ignitions for 60min at 550℃. IGs were measured in 2.4~16.2% in Daecheong, 3.8~17.3% in Sapkyo and 4.8~18.7% in Kumkang reservoir.

It is shown that weight loss on ignition increases as the depth of sediment increases. Especially, IG values of the 2nd samples in Daecheong reservoir were measured in some higher than the 1st samples and so it can be concluded that the sediment of Daecheong reservoir was formed by the precipitation of organic matter inflowed during the flood-season. But, IGs of the 2nd samples in Sapkyo and Kumkang were measured lower than the 1st samples. It could be explained that Sapkyo and Kumkang reservoirs were constructed to protect the sea water for irrigation of rise field area. Water gate shut down or shut up for the regular water levels, threrefore organic matter on the top-layer of sediment could not be sustained for a long time.

Table 2. General items of sediment sample

Sites \ Item		Water depth(m)		Sediments Depth(cm)		Water Content(%)		IG(%)		Porosity(%)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Munee	Point 1	20	19	11	15	59	51	2.4	10.1	79.0	76.5
	Point 2	19	17	14	18	62	59	14.5	12.2	78.0	76.0
	Point 3	18	18	16	16	63	68	12.1	12.0	77.0	77.0
	Point 4	19	20	17	17	61	70	11.8	12.4	79.0	75.0
Chudong	Point 1	16	15	14	12	56	45	9.6	11.6	79.3	85.9
	Point 2	14	12	15	16	59	50	10.5	9.2	78.5	80.0
	Point 3	13	13	16	15	60	52	10.8	13.0	77.3	75.3
	Point 4	15	14	18	22	62	53	10.8	13.1	77.7	77.1
Hoenam	Point 1	28	25	14	13	54	45	10.8	9.6	76.7	69.5
	Point 2	25	24	18	22	59	48	10.3	11.2	76.4	68.4
	Point 3	26	23	20	24	58	49	10.3	10.8	75.9	65.3
	Point 4	27	24	24	20	57	47	11.1	16.2	74.8	62.1
Chusori	Point 1	23	21	22	20	51	41	8.9	10.7	84.6	64.6
	Point 2	22	20	26	20	63	50	8.9	12.3	83.2	63.5
	Point 3	24	19	25	19	62	64	9.8	12.5	80.4	64.2
	Point 4	20	18	27	21	68	66	9.2	12.3	79.0	65.1
Sapkyo 1	Point 1	5	6	26	30	38	34	5.6	8.1	76.1	73.2
	Point 2	8	8	17	33	54	28	17.3	7.9	80.3	66.6
	Point 3	7	12	15	34	56	27	10.8	8.0	81.3	57.1
	Point 4	6	14	20	33	63	27	11.4	9.9	74.9	67.9
Sakyo 2	Point 1	7	10	34	12	58	42	11.1	8.0	82.6	70.2
	Point 2	14	18	30	26	52	33	8.0	3.8	80.0	69.2
	Point 3	20	21	15	30	50	32	27.9	9.2	78.9	55.8
	Point 4	19	19	14	29	49	48	13.8	12.8	76.1	70.1
Kumkang 1	Point 1	8	11	29	7	47	26	11.9	12.8	80.3	66.2
	Point 2	9	13	18	12	54	45	10.2	12.7	88.4	84.9
	Point 3	10	15	18	15	66	61	13.0	8.4	76.4	79.2
	Point 4	12	12	17	16	30	23	9.9	7.8	78.2	74.0
Kumkang 2	Point 1	19	14	32	30	61	67	10.2	4.8	78.3	79.4
	Point 2	15	17	28	28	49	45	18.7	5.4	82.3	76.9
	Point 3	21	20	14	17	60	48	13.2	7.2	82.4	80.7
	Point 4	14	16	20	16	47	42	8.7	7.7	81.9	79.8

2. Phosphorus Content in Sediment

Bottom sediment is known to play an important role in the nutrient release. Generally, in a lake restoration program, it cannot be ignored the effect of the sediments on the phosphorus budget. Even if the restoration program has been completed, there was a examples where water quality did not improved to the desired levels because of phosphorus release from the sediment[15].Many studies have reported on the rate of phosphorus release from the sediment. And these studies were conducted under defined environmental conditions, aerobic or anaerobic, using specific lake sediments(Fillos and Swanson, 1975[16]; Freedman and Canale, 1977[17]). These results, however, differ greatly from case to case, even among sediment sample from the same lake, depending on the experimental conditions and/or characteristics of sediment.

So the purpose of this section was to clarify the relationship between the amount of various fractions of phosphorus contained in the sediment. Phosphorus in the sediment was fractionated to each bounded forms before and after phosphorus release. The value ranges of TP were in 807~1,542μg/g in the 1st samples and 677~5,238μg/g in the 2nd at all reservoirs. Over all, the variations of phosphorus content in the 1st samples were more fluctuated than the 2nd samples. Theoretically, it is very difficult to extract phosphorus by NH_4Cl solution. But, some of fraction of NH_4Cl-P was extracted and its value were 0.564~22.0 μg/g and 0.169~3.323μg/g in each sampling periods. In the inorganic phosphorus, Fe-P contents extracted by 0.1M NaOH solution were measured in highst values. Incase of Fe-P, Hosomi[18] said that both the amount of aerobically released phosphorus and maximum growth yield of algae were proportional to Fe-P fraction in the sediment and the amount of released phosphorus was about 90% of the Fe-P fraction in the sediment. In our experiment, fraction of Fe-P was measured at maximum values in inorganic phosphorus fractions. And organic fractions was proportional to the TP content of sediments. And it was found that release rate of phosphorus was not related in so much as phosphorus content in sediment. For example, in Hoenam area of the 2nd sample period phosphorus content of sediment was measured in most largest values but phosphorus release rate was not measured in highest values. In Daecheong reservoir, contents of the 1st sampling period were determined more higer than the 1st sampling period. But, compared with in each sampling periods of Hoenam area, variation of TP values were more variable than other sampling sites in Daecheong reservoir. This phenomenon could be explained by the fact that this area was located in many fish farms so much fish-feed which were not obtained by fish was accumulated on the toplayer of sediment.

In Sapkyo and Kumkang, there were more variable in TP contents than Daecheong. This phenomenon could be explained as followings; There were many tributaries in Sapkyo and Kumkang induced in main streams, so accumulations of sediment particles would be easily altered. And flowings of main stream could not permit to sustain the humus on the top layers of bottom sediments, so total contents of phosphorus and inorganic contents were more variable than Daecheong reservoirs. And these characteristics were shown in nutrients release rates, similarly. But most of all, detention-time of water body was major roles in this traits. In Daecheong reservoir, detention-time of waterbody was known in 105 days, but in case of Sapkyo and Kumkang detention-time of waterbody were known in 7~9 days.

Table 3. Phosphorus contents in sediment

Sites \ Items		T-P(㎍/g)		Inorganic-Phosphorus(㎍/g)								O-P(㎍/g)	
				NH_4Cl-P		Al-P		Fe-P		Ca-P		TP-IP	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Munee	Point 1	1193	1196	-	-	0.139	0.457	427	458	0.885	0.969	765	737
	Point 2	1222	787	-	0.211	0.028	0.371	428	458	1.542	0.642	793	329
	Point 3	1086	677	-	0.436	0.202	0.291	440	481	1.868	0.402	646	195
	Point 4	1280	1041	-	0.269	0.245	0.046	459	494	0.665	0.639	820	547
Chudong	Point 1	1056	772	22	0.275	0.471	1.260	463	360	12.055	0.478	593	411
	Point 2	807	805	-	-	0.949	0.420	328	373	1.347	0.733	478	161
	Point 3	1360	842	0.058	0.926	0.585	0.522	421	343	1.925	0.792	938	498
	Point 4	1260	880	0.257	0.319	5.176	0.371	431	400	2.150	0.889	828	480
Hoenam	Point 1	1431	5238	-	3.323	0.712	0.116	545	1079	0.804	1.891	886	4159
	Point 2	1511	2190	-	0.431	0.723	1.297	482	958	0.361	1.610	1028	1231
	Point 3	1382	2520	-	1.034	0.499	0.753	549	978	1.531	1.652	832	1541
	Point 4	1437	1951	1.120	0.430	1.076	0.125	569	818	0.870	1.039	867	1133
Chusori	Point 1	1396	939	0.609	0.295	0.694	0.207	630	367	1.034	1.543	766	571
	Point 2	1400	917	0.319	0.402	1.232	0.085	618	351	0.014	0.706	782	565
	Point 3	1542	987	1.048	1.076	0.217	0.788	582	496	2.487	0.388	960	491
	Point 4	1521	767	0.564	0.169	0.708	0.103	615	457	1.475	0.163	906	309
Sapkyo 1	Point 1	764	1082	0.944	-	1.123	0.162	474	623	1.706	0.765	286	458
	Point 2	943	1002	-	-	1.012	0.133	647	766	0.331	0.131	294	235
	Point 3	780	897	-	0.033	0.182	0.234	476	677	0.113	2.120	303	217
	Point 4	833	998	-	-	0.624	0.542	328	619	0.911	0.759	503	377
Sakyo 2	Point 1	1417	1087	-	0.072	0.184	0.297	509	298	0.596	0.450	907	788
	Point 2	674	800	0.334	0.004	0.030	0.246	508	596	0.940	1.077	164	202
	Point 3	1326	987	-	3.160	2.170	0.462	551	695	0.911	0.329	771	288
	Point 4	1260	1027	-	-	1.027	0.155	621	594	0.118	0.930	637	431
Kumkang 1	Point 1	1452	848	0.684	-	0.044	0.435	534	488	0.394	0.493	916	359
	Point 2	690	960	0.244	-	0.021	0.624	526	690	1.170	0.711	162	268
	Point 3	960	890	-	-	1.270	0.234	435	354	7.110	0.96	524	534
	Point 4	1250	884	-	-	0.651	0.331	421	464	1.600	0.266	826	419
Kumkang 2	Point 1	761	604	-	0.157	0.156	0.855	585	180	1.166	0.353	174	422
	Point 2	868	671	-	-	0.485	0.432	464	192	0.755	0.299	402	478
	Point 3	972	735	0.099	0.200	1.989	0.313	551	270	0.738	0.692	418	463
	Point 4	621	729	-	0.572	2.057	0.527	479	291	0.672	0.992	139	435

3. Release Rate of Nutrients

The release rate of nutrient such as PO_4-P and NH_4-N is very important because water quality of reservoir is directly influenced by the release ratio of nutrient from bottom of sediment. So,this study make an effort to deduce the relationship between water quality of overlying water and interstitial water of sediment. Basically the diffusion of substancesinterrelates with the difference of concentrations. Based on this phenomenon, we could calculate the release rate of nutrients which is regarded as most important factor of water bloom in water temperature elevating season. So, in the first step, the concentrations of PO_4-P and NH_4-N in the interstitial and in the overlying water were measured to determine their release rates as shown in Table 4. In the second step,by usingthe concentration differencesrelease rates were calculated as shown in Table 5.

Generally, PO_4-P and NH_4-N concentrations in the interstitial water were determined much higher than those in the overlying water. In Daecheong reservoir, the concentrations of PO_4-P and NH_4-N in the interstitial and in the overlying water were in the range of 0.02~ 1.531mg/L and 0.005~ 4.471mg/L. As shown in Table 5, in most areas except Munee, the NH_4-N release rate were measured higher in the 1st samples than the 2nd samples, which indicates that NH_4-N was released from sediments as the degradation process progressed during water temperature elevating season. Compared with the results, it was found that NH_4-N and PO_4-P concentrations in the interstitial water are relatively high in fish farms such as Hoenam area and in the embayment like as Chusori area. Especially, Chusori area in the first sampling period, NH_4-N and PO_4-P concentrations in the interstitial water were measured most highly. In Sapkyo reservoir,the concentration ranges of PO_4-P and NH_4-N were determined 0.001~0.202mg/L and 1.408~6.514mg/L. And in Kumkang reservoir, concentration ranges of PO_4-P and NH_4-N were 0.002~0.252mg/L and 0.237~ 6.398mg/L. Compared with Daecheong reservoir, the variation of concentration differences are more severly fluctuated. From this result, it could be estimated that the mobility of sediment are more activated than Daecheong reservoir because of water body movement is regularly maintained for the certain level. So, phosphorus release rate of sapkyo and Kumkang were determined relatively low level compared with Daecheong reservoir.In these reservoir, ranges of phosphorus and nitrogen release rate were calculated in $8.31x10^{-3}$~$2.01x10^{-2}$mgP/m^2/day and 0.89~4.42mgN/m^2/day. Compared with release rate of Daecheong reservoir, values of these reservoirs were detected relatively low levels. These phenomena could be explained like that there was no time for accumulation of sediment. Therefore, humus on the sediment coud not be decomposed sufficiently, so release of nutrient could not be generated. And, in this respect, the hydrological structure of Sapkyo and Kumkang reservoir was different from the Daecheong reservoir.

4. Determination of Humus Level

Organic sediments in reservoir and lakes are like the uppermost horizon in soils, a mixture of minerogenic matter and remains of plants and animals. Humus is a brown, grey or black substance whose chemical composition is still largely unknown. From a chemical point of view, acid humus is presumed to be an unsaturated sol with a negatively charged particles, and neutral humus is thought to be a gel

Table 4. Concentrations of the dissolved nutrients in the interstitial and overlying water

Sites \ Items		PO_4-P (mg/L)		NH_4-N (mg/L)	
		1st	2nd	1st	2nd
Munee	overlying	0.020	0.011	0.336	0.162
	interstitial	0.205	0.190	1.004	1.885
Chudong	overlying	0.015	0.003	0.251	0.075
	interstitial	0.939	0.051	1.711	1.020
Hoenam	overlying	0.028	0.019	0.179	0.311
	interstitial	0.593	0.039	2.086	4.471
Chusori	overlying	0.046	0.005	0.695	0.165
	interstitial	1.531	0.092	4.617	3.091
Sapkyo 1	overlying	0.202	0.021	3.641	7.261
	interstitial	0.155	0.004	2.309	2.645
Sapkyo 2	overlying	0.182	0.007	6.514	5.200
	interstitial	0.122	0.001	1.297	1.408
Kumkang 1	overlying	0.189	0.032	5.337	2.741
	interstitial	0.170	0.002	2.309	0.237
Kumkang 2	overlying	0.252	-	6.398	-
	interstitial	0.119	-	2.297	-

Table 5. Release rate of PO_4-P and NH_4-N

Sites \ Item	Diff. coeff. of phosphorus ($\times 10^{-5} m^2/day$)		Release rate ($mgP/m^2 day$)		Diff. coeff. of NH4-N ($\times 10^{-5} m^2/day$)		Release rate ($mgN/m^2 day$)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Munnee	5.90	5.16	0.85	0.70	9.46	8.27	4.90	10.95
Chudong	6.22	6.57	4.56	0.26	9.98	1.05	11.57	8.56
Hoenam	6.01	4.27	2.60	0.05	9.64	6.84	36.56	10.96
Chusori	6.87	3.59	8.63	0.20	1.10	5.77	13.97	19.86
Sapkyo 1	3.06	2.85	2.01×10^{-2}	6.02×10^{-3}	4.91	4.57	2.28	2.77
Sapkyo 2	3.57	2.66	3.23×10^{-2}	1.83×10^{-3}	5.72	4.27	3.22	1.97
Kumkang 1	3.29	2.35	8.92×10^{-3}	8.31×10^{-3}	5.29	3.77	0.89	1.12
Kumkang 2	3.39	-	6.51×10^{-2}	-	5.44	-	4.42	-

where anions are adsorbed to the surface of the humus particles. In sedimentologies, a distinction between two types of humus is very important. This can be expressed as the content of organic carbon and by the carbon and nitrogen ratio. About the humus level of sediments, Hansen[19] said in his paper

Table 6. Elelment content of sediment

Sites	Items	Carbon(%)		Hydrogen(%)		Nitrogen(%)		Sulfur(%)		C/N	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Munee	Point 1	1.756	1.621	0.919	0.771	0.152	0.175	ND	ND	11.5	9.2
	Point 2	2.119	2.002	1.140	0.869	0.189	0.251	ND	ND	11.2	7.9
	Point 3	1.945	1.487	1.097	0.720	0.156	0.199	ND	ND	12.4	7.4
	Point 4	2.080	1.636	1.238	0.877	0.194	0.219	ND	ND	10.7	7.4
Chudong	Point 1	1.656	1.415	1.001	0.582	0.177	0.185	ND	ND	9.3	7.6
	Point 2	1.491	1.469	0.753	0.675	0.113	0.182	ND	ND	13.1	8.0
	Point 3	2.229	1.374	1.203	0.698	0.191	0.170	ND	ND	11.6	8.0
	Point 4	2.235	1.361	1.236	0.727	0.206	0.170	ND	ND	10.8	8.0
Hoenam	Point 1	1.644	1.935	1.207	0.725	0.187	0.225	ND	ND	8.7	8.6
	Point 2	1.644	1.629	1.224	0.715	0.167	0.202	ND	ND	9.8	8.0
	Point 3	1.736	1.657	1.043	0.740	0.169	0.212	ND	ND	10.2	7.8
	Point 4	1.921	1.774	1.340	0.749	0.155	0.226	ND	ND	10.8	8.5
Chusori	Point 1	1.984	1.472	1.043	0.517	0.183	0.187	ND	ND	10.8	7.8
	Point 2	2.511	0.562	1.069	0.760	0.213	0.182	ND	ND	11.7	3.0
	Point 3	2.629	1.908	1.125	0.855	0.230	0.232	ND	ND	11.4	8.2
	Point 4	2.716	1.623	1.032	0.849	0.212	0.187	ND	ND	12.8	8.6
Sapkyo 1	Point 1	0.680	1.208	0.651	0.729	0.064	0.153	ND	ND	10.6	7.8
	Point 2	1.002	1.094	0.528	0.738	0.077	0.152	ND	ND	13.0	7.1
	Point 3	1.542	1.054	1.023	0.657	0.148	0.149	ND	ND	10.4	7.3
	Point 4	1.301	1.048	1.100	0.592	0.183	0.134	ND	ND	7.1	7.8
Sakyo 2	Point 1	1.564	0.923	1.186	0.712	0.171	0.145	ND	ND	9.1	7.2
	Point 2	0.820	1.654	0.695	0.522	0.068	0.132	ND	ND	12.0	6.9
	Point 3	1.085	0.816	2.209	0.967	0.166	0.216	ND	ND	6.5	7.6
	Point 4	1.204	0.918	1.681	0.517	0.102	0.120	ND	ND	9.2	6.8
Kumkang 1	Point 1	1.785	1.578	1.343	1.433	0.193	0.130	ND	ND	8.1	12.1
	Point 2	1.100	1.001	1.604	0.972	0.111	0.101	ND	ND	9.9	9.9
	Point 3	1.345	1.548	1.433	1.278	0.143	0.223	ND	ND	9.4	6.9
	Point 4	1.114	0.901	1.004	1.009	0.264	0.246	ND	ND	4.2	3.6
Kumkang 2	Point 1	1.543	0.668	1.161	0.397	0.173	0.074	ND	ND	8.9	9.0
	Point 2	1.249	0.554	0.681	0.299	0.119	0.058	ND	ND	10.4	9.3
	Point 3	1.181	1.020	0.893	0.513	0.115	0.120	ND	ND	10.2	8.5
	Point 4	1.128	1.028	0.651	0.583	0.089	0.134	ND	ND	12.6	8.0

published in 1959 that if the organic content of organic carbon is less than 50 percent and the the C/N ratio less then 10 the humus is neutral, and if the content of organic carbon is higher than 50 percent and C/N ratio is higher than 10, the humus is acid. In this paper, content of organic carbon and organic nitrogen wolud presumed to be well fitted content of elemental content by elemental analysis. Because the combustions of sediment were conducted in the reactor tube(ca. 1800℃), all organic substance would be combustioned. So, organic contents of nitrogen and carbon obtained by titration were not used in this work. In this study, based on Hansen and H kanson' s theories we could obtain humus levels of reservoirs. The C/N ratios for sediments determined using elemental analyser were shown in Table 3. In the case of Daecheong reservoir, the C/N ratios were in some higher in most area in 1st sampling period than the 2nd. Therefore, in 1st sampling period, it could be concluded that decomposition rate of organic materials is faster than 2nd sampling period. And in 2nd sampling period, C/N ratios of all areas were measured below than 10.Compared with C/N ratios in sampling periods, it could be predicted that the decomposition rate of organic materials would be more faster in 1st sampling period than 2nd sampling period. And in the case of Sapkyo and Kumkang reservoir C/N ratio were determined in 6.8~13.0 in Sapkyo and 3.6~12.6 in Kumkang. The trends of C/N ratio could be explained as similar pattern of Daecheong reservoir. General features of all reservoirs examined could be summurized such as ; First, if IGs were measured highly, C/N ratios were determined lower values, relatively. Second, C/N ratios of the 1st sampling period were measured higher than the 1st. Third, fluctuation of values of element contents were more variable Sapkyo and Kumkang reservoirs than Daecheong reservoir. As shown in from Fig. 4 to Fig. 6, humus level of sediments in Daecheong, Sapkyo and Kumkangreservoir was estimatedoligohumic and mesohumic states.

Ⅳ. Conclusion

1. IG values were measured in the range of 2.4~16.2% in Daecheong, 5.6~27.9% in Sapkyo, 7.2~18.7% in Kumknag, respectively. And, porosities were determined in 62.1~85.9% in Daecheong, 55.8~88.4% in Sapkyo, 74.0~82.4% in Kumkang. Viewing the results of porosities, constituents particles of sediments would be conjectured silty or sandy particles.

2. TP content of sediment were 674~5,238㎍/g in Daecheong, 674~1260 ㎍/g in Sapkyo, 621~1,452㎍/g in Kumkang. Inorganic phosphorus was proportional to the TP content. Over all, phosphorus relaese rate and phosphorus content in sediment were not interrelated in so much as we expected.

3. Release rate of nutrients were determined in 0.05~8.63mgP/m^2day and 4.99~36.56mgN/m^2day inDaecheong, $1.83x10^{-3}$~$3.23x10^{-2}$mgP/m^2day and 1.97~3.22mgN/m^2day in Sapkyo, $8.92x10^{-3}$~$6.51x10^{-2}$mgP/m^2day and 0.89~4.422mgN/m^2day in Kumkang.

4. Carbon to nitrogen ratios were 3.0~13.1 in Daecheong, 6.8~13.0 in Sapkyo, 3.6~12.6 in Kumkang, respectively. It implies that the humus level of sediments would be changed from oligohumic to mesohumic state for an interval of three months between the first and the second sampling periods.

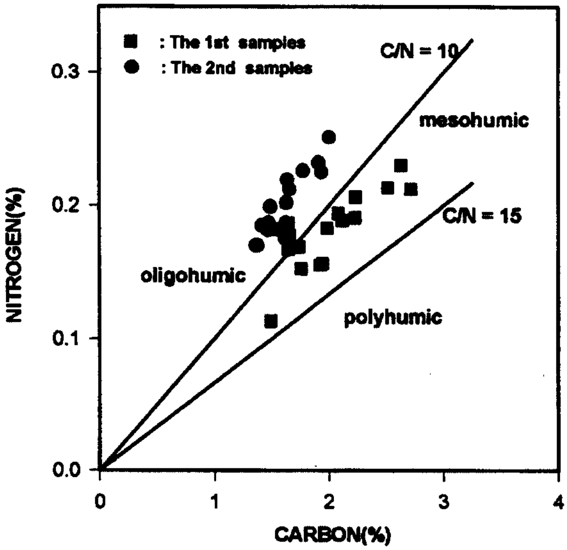

Fig 4. Nitrogen content versus carbon content in sediment samples from Dae-Cheong reservoir.

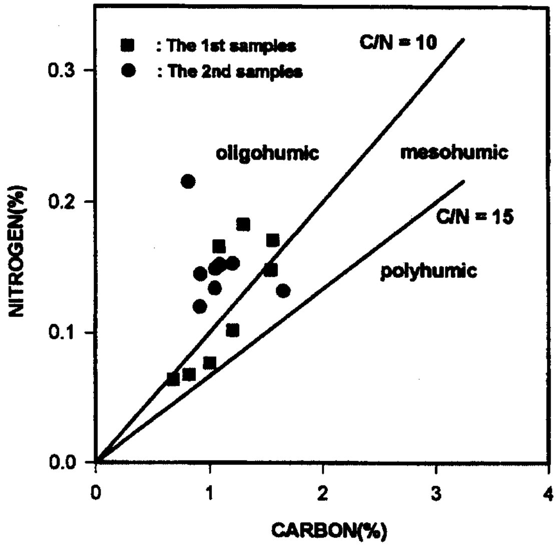

Fig 5. Nitrogen content versus carbon content in sediment samples from Sap-Kyo reservoir.

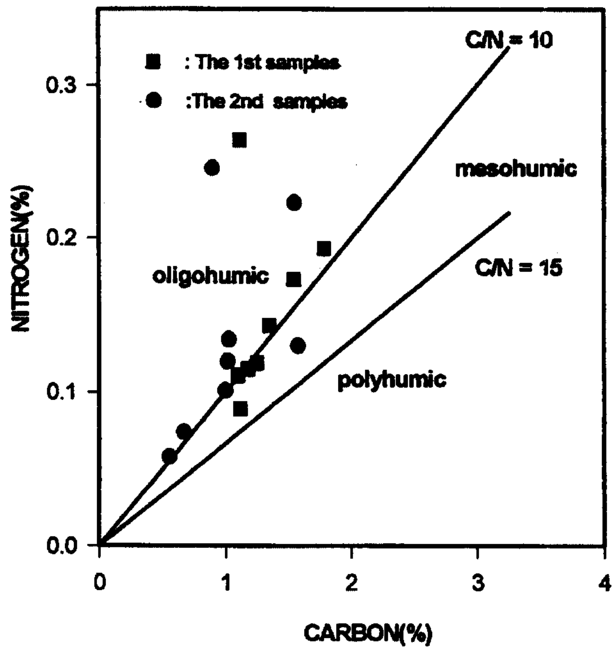

Fig 6. Nitrogen content versus carbon content in sediment samples from Kymkang reservoir

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