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한국에서의 질소와 인의 부하량 산정

Calculation of the loading of nitrogen and phosphorus in Korea

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Introduction

Recently the most water system such as lakes, reservoirs and stream are growing worse water quality because of input of pollutant materials so that grade of raw water quality show 2-3 grade. Particularly input of phosphorus and nitrogen from watershed has been identified as a significant source of water quality pollution such as eutrophication ,and eutrophication of most fresh water around the world is accelerated by phosphorus inputs(Schindler, 1977; Sharpley et al., 1994).

The main cause of impaired surface water quality due to input to watershed of pollutants such as domestic and industrial sewage, manure from livestock, runoff of farm land in storm runoff. In particular, the loss of Phosphorus and Nitrogen in surface runoff and subsurface flow of farm land occur with heavy storm runoff(Krenkel et al., 1980).

Pollution sources can be generally categorized point source and nonpoint source. Point source refer to polluted effluent from directly and extremely small area. Examples of pollutions are domestic or industrial wastewater, and the route and quantity of such pollutions are easily measured or controlled(Choe et al. 2002). In contrast, nonpoint source, once known as "diffuse" source, arises from a broad group of human activities for which the pollutants no obvious point of entry into receiving watercourses(FAO, 1996). Examples of nonpoint source are animal feedlots, irrigation of land, forest, urban runoff, runoff from mines, atmospheric deposition. Obviously, nonpoint source is much more difficult to identify, measure and control than point sources. Also, the quantity of loading due to runoff of nonpoint sources is not easy because variation of flow and concentration according to the rainfall is very high.(Tanaka, 1990).

In most industrialized countries, the focus on water pollution control has traditionally been on only point source management, although increasing a view of the known impact of nonpoint source of which agriculture has the largest overall and pervasive impact, increasingly. US-EPA(1992) reported on the ranking of sources of water quality deterioration in river, lakes and estuaries. The most important pollution sources are agriculture and urban runoff. Robert G. Jr.(1991) identified that 50-70% of assessed agriculture as the leading cause of water quality impairment of rivers and lakes, also assessed 5-15% in urban runoff , 5-15% in Hydromodification, 1-5% in mining and silviculture.

Animal manure can be a valuable resource for improving soil structure and increasing

vegetative cover, thereby reducing surface runoff and erosion potential. However, the rapid growth and intensification of crop and animal farming in many areas has created regional and local imbalance in phosphorus and nitrogen inputs and outputs.

Until now, evaluation of loading of nitrogen and phosphorus has studied by Unit of pollutants that already many research and study have known. In this study, loading of total phosphorus and nitrogen in korea had calculated by pollutant loadings of nonpoint source categories. Loading of P and N from agriculture and livestock calculated by fertilizer consumption, feed production, and loading of P and N from urban runoff, people, forest calculated by unit.

Also, this study evaluate loading of phosphorus and nitrogen due to feed(livestock) and fertilizer (agriculture) among the all nonpoint source categories. At last study, each regional area or watershed area make an investigation into consumption of fertilizer and feed at agricultural farm land, and attempting to provide the basic data to establish a proper research and process.

Methods and material

Data for nutrient sources were developed for five major source categories: (1) commercial fertilizer, (2) animal feed, (3) people, (4) urban runoff, (5) forest.

1. Loading of nitrogen and phosphorus from fertilizer

Generally, kind of fertilizer use for farm land can divided nitrogen(N) fertilizer, phosphorus(P_2O_5) fertilizer and potassium(K) fertilizer, complex fertilizer. The most use of the fertilizer is complex fertilizer.

The consumption of fertilizer are based on fertilizer sales data on Yearly statistic report of Agriculture and Marine products(1996) and Yearly report of fertilizer(1995). Total loading of nitrogen and phosphorus calculated that every quantity of fertilizers multiplied content of nitrogen and phosphorus among fertilizer.

2. Loading of nitrogen and phosphorus from feed

A kind of feed and quantity of use feed are very different according to kind of animal and age. Also, the nutrient content of animal feed is different each fertilizer company.

The loading of Nitrogen and phosphorus from consumption of animal feed are based on nation surveys of animal populations and literature data on feed sales data and the nutrient content of animal feed. Total loading of nitrogen and phosphorus calculated that every quantity of fertilizers multiplied content of nitrogen and phosphorus among feed.

3. Loading of nitrogen and phosphorus from other sources

Unit of pollution loading has been used as Indirect method in order to evaluate loading of pollutants in watershed. In particular, when direct measurement is impossible, Unit is usable method.

In this study, people, forest sources are based on Unit by Mitsumasa Okada *et al.*(1986) and 湖沼環境調査指針(1984). Urban runoff is based on Unit by J. S. Choe *et al.* (2002). Data on the source inputs and terrestial characteristics were referenced to Yearly statistic report of Agriculture and Marine products(1996). Population is about 43,000,000, total territorial area is 9,931,300ha, total agricultural land is 1,945,480ha, and paddy field and upland are 1,176,148ha and 769,332ha, respectively.

Result and discussion

1. Loading of nitrogen and phosphorus from fertilizer

Until now, the consumption of fertilizer generally two times increase from 1982 to a level 233.2 kg/ha/yr to 1994 to a level 439.9 kg/ha/yr, and more large increase of nitrogen fertilizer than phosphorus fertilizer from 1993 to 1994(Fig. 1).

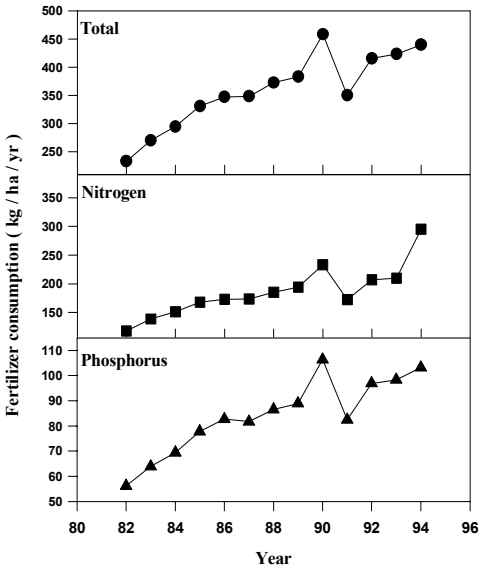

Fig 1. Fertilizer consumption per unit area in Korea (1982 - 1994)

In Europe, Nutrient application to agricultural land includes inorganic fertilizer and manure. The consumption of fertilizer generally increase from 1970 to 1988, the consumption has decreased in recent year.(EEA, 1999).

The production of complex fertilizer is much more than production of others fertilize-complex fertilizer 65%, nitrogen fertilizer 33%, phosphorus fertilizer 4%. And the long-term use of complex fertilizer has increased the many agricultural land to excessive level.

A large quantity use of complex fertilizer would not be expected to good agricultural land. After find out empty nutrient at agricultural land, to supply of fertilizer as much as need is most suitable method.

Loading of Nitrogen and Phosphorus calculated by production of fertilizer are evaluated

992,153 tonN/yr and 231,976 tonP/yr. And loading of Nitrogen and Phosphorus calculated by consumption of fertilizer are evaluated 467,778 tonN/yr and 133,407 tonP/yr(Table 4).
The comparison between consumption of fertilizer and Unit method, loading by consumption of fertilizer higher about 4 times(nitrogen) and 17 times(phosphorus) than loading by Unit method(Table 6).

Table 4. The amount of nitrogen, phosphorus from annual consumption of fertilizer in Korea(1994)

Fertilizer Type	Consum. (ton)	P_2O_5 %	P %	N %	P (ton/yr)	N (ton/yr)
N Fertilizer						
硫安	21,319			0.21		4,477
尿素	457,957			0.46		210,660
Sum	479,276					215,137
P Fertilizer						
熔成燐肥	2,996	0.2	0.086		258	
熔過燐	51,149	0.2	0.086		4,399	
過石	10,976	0.2	0.086		944	
Sum	65,121				5,601	
Complex Fertilizer	1,486,124	0.2	0.086	0.17	127,807	252,641
Total	2,030,521				133,408	467,778

source) Ministry of agriculture and forest(1996)

Table 6. The comparison of consumption of fertilizer, feed and unit discharge in Korea

Item	Fertilizer		Feed	
	Calculated from fertilizer consumption	Estimated by unit discharge	Calculated from feed production	Estimated by unit discharge
Nitrogen (tonN/yr)	467,778	107,592	397,743	303,423
Phosphorus (tonP/yr)	133,408	7,704	73,707	221,200

source) Ministry of agriculture and forest(1996), KAIST(1990):unit of livestock
田淵俊雄(1985):unit of paddy, upland, others , 湖沼環境調査指針(1984):unit of forest

2. Loading of nitrogen and phosphorus from feed

Now, the quantity of feed production is 15,783,468 ton/yr, cow feed took the most high percentage, all of 40%. Loading of Nitrogen and Phosphorus calculated by production of feed are evaluated 397,743 tonN/yr and 73,707 tonP/yr. The production of feed generally increase from 11,000,000 ton in 1991 to 16,000,000 ton in 1996(Table 8).

Table 8. Yearly variation of feed production and amount of nitrogen, phosphorus generation by feed consumption in Korea(1991 - 1996)

Year	Feed Production ton/yr	Nitrogen ton/yr	Phosphorus ton/yr
1991	11,482,973	289,773	54,407
1993	13,027,062	327,505	61,208
1994	13,554,871	343,850	63,897
1995	14,695,376	371,389	69,017
1996	15,783,468	397,743	73,707

source) 1. Ministry of agriculture and forest(1996)
2. Feed(1992-1997), Korea Feed Association
3. Korea Feed Industry Association(1996)

At loading of Nitrogen and Phosphorus calculated by production of feed, loading from pig of total loding evaluated most high percentage as each 34% and 40%.

The estimation of nutrient loading of livestock generally calculated by Unit of livestock manure. The total production of livestock manure in Korea was about 36,000,000 ton/yr. For total livestock manure, the contribution of cow value about 52%, show the most high contribution. For total loading of nitrogen and phosphorus, the loading and contribution of cow and poultry showed each 121,193 tonN/yr(40%) and 75,160 tonP/yr(34%)(Table 9).

Table 9. The discharge of livestock waste in Korea calculated by unit discharge coefficient(1995)

		Korean native cattle	Dairy cattle	Pig	Chicken	Total
Head		2,594,027	553,467	6,461,179	85,799,729	
N	unit (kg/head/day)	0.128	0.126	0.02	0.0035	
	Discharge (ton/yr)	121,193	25,454	47,167	109,609	303,423
P	unit (kg/head/day)	0.072	0.187	0.017	0.0024	
	Discharge (ton/yr)	68,171	37,777	40,092	75,160	221,200

source) Ministry of agriculture and forest(1996), KAIST(1990)

The comparison between production of feed and Unit method by livestock manure, loading of phosphorus showed that Unit method much larger 3 times than feed production(Table 6).

The link between feed production and livestock concentration in the Midwest does allow, in many instances, for land application of animal manure and recycling of the nutrients in the crop production system, but that does not mean that all manure is now being handled adequately(USDA, Dec. 1996).

3. Loading of nitrogen and phosphorus from people, urban-runoff and forest

Loading of nutrients(N, P) evaluated by Unit of people, urban runoff and forest. Among the three sources, people showed higher contribution than urban runoff, forest. Loading of nitrogen and phosphorus by people were each 219,730 tonN/yr and 29,820 tonP/yr. The order of contribution was people > urban runoff > forest(Table 11).

Table 11. The discharge of nitrogen and phosphorus from pollutant sources in Korea.

source	Num.	N ton/yr	P ton/yr	unit	Refer.
Peoples	4,300 $\times 10^4$	219,730	29,820	N=5.1kg/h/yr P=0.69kg/h/yr	Mitsumasa Okada *et al.*,(1986)
Feed	15,783,468 ton/yr	397,743	73,707	Feed production (1996)	.
Fertilizer	2,030,521 ton/yr	467,778	133,408	Fertilizer Consumption (1994)	.
Urban	6,455,550 ha	72,300	20,856	N=52kg/ha/yr P=15kg/ha/yr	J. S. Choe *et al.*(2002)
Forest	6,455,550 ha	30,160	1,178	N=4.67kg/ha/yr P=0.183kg/ha/yr	日本湖昭環境調査指針 (1985)
Total		1,187,711	258,969		

4. Loading of nitrogen and phosphorus from individual source categories

From Table 11, it is clear that relative importance of the different categories of nutrient sources in korea. Feed and fertilizer as agricultural activity generally represent the highest contributors to nitrogen and phosphorus export from watershed. Fertilizer is the most large contributor to nutrient loads in watershed. Contribution rate of nitrogen and phosphorus from fertilizer is 39 % and 52 % respectively. Specially, fertilizer contribute more than half of the total phosphorus. Feed is also an important contributor of both nitrogen and phosphorus in watershed, percentage of nitrogen and phosphorus are 34% and 28%. The added percentage contribution by fertilizer and feed to nitrogen and phosphorus show 77 % and 87 %, respectively. According to the result of Italian (ISTAT) 1990 agricultural census data, apportionment of Livestock of N and P budgets measured 22.4% and 12.5%, also fertilizer application of N and P budgets are 27.3% and 24.1%.(WRc/TEi, 1997).

Phosphorus loading generally increases with increasing human activity in the catchment. In the more densely populated areas, about 50-80% of the most of phosphorus load to inland water is derived from point sources, while agricultural activity generally accounts for 20-40%(EEA, 1999). Nitrogen pollution is usually dominated by nonpoint sources, in particular agricultural activities. In the central and western part of Europe, 46-87% of the nitrogen load to inland waters is related to agriculture(EEA, 1999).

In case of United States, apportionment of Livestock of N and P export from watershed measured 14% and 26%, also fertilizer application of N and P export from watershed are 22% and 17%(Smith, 2000).

Conclusion

Until now, to estimate of nutrient loading at many study about nonpoint source has been used the Unit load. This Unit load apply many study but direct use of Unit load is many problems for high irregular variation such as terrestrial characteristic, climate, soil, farmer etc. in watershed.

Estimating the importance of nonpoint as a source of nutrients in watershed is made difficult by the diverse and ubiquitous nature of nitrogen and phosphorus forms in the environment. The relative estimation of nutrient sources is most important in study of nonpoint source.

In this study, direct calculation method were used to estimate nutrient contribution from five source categories. People and forest generally contribute little to nutrient export from most of the nation's watersheds. Urban-runoff is the medium contributor to export of watershed.

The most importance sources are fertilizer and feed, individual nutrient loading by fertilizer and feed are 467,778 tonN/yr, 133,408 tonP/yr and 397,743 tonN/yr, 73,707 tonP/yr.

The order of nutrient contribution of five source categories is Fertilizer > Feed > People > Urban-runoff > Forest. Fertilizer is an important and largest contributor to export of nutrient in nation' watershed.

Total loading of nitrogen and phosphorus of five source categories in nation' watershed is 1,187,711 tonN/yr and 258,969 tonP/yr. The contribution about nitrogen and phosphorus by fertilizer and feed in five source categories evaluate 77 % and 87 %, respectively.

Recently, the contribution of individual nutrient sources to water quality is not directly measurable in large watershed, therefore must be estimated using a watershed model. In further study, many information of individual watershed and region -watershed characteristic, soil type, climate, rainfall, management of fertilizer and feed, land management, etc. - exactly investigate, so that nutrient loading of many source categories in watershed could be evaluate more accurately.

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