# STATUS OF SHALLOW GROUNDWATER QUALITY WITH STACK OF ANIMAL WASTE

Jong-Sik Lee, Jin-Ho Kim, Sun-Gang Yun, and Mun-Hwan Koh.

*Dept. of Environment & Ecology, Nat'l Inst. of Agri. Sci. & Tech., RDA Suwon, 441-707, KOREA*

## ABSTRACT

Animal waste stacked near the livestock farm is one of the pollution sources in rural areas. To find out the affect of stacking animal waste on environment at the livestock farming areas, shallow ground water was sampled and analyzed. Results showed that the concentration of $NH_4$-N in shallow ground water was high at stack site, however, $NO_3$-N concentration was high at downstream. It showed that $NH_4$-N, which is a mineralized form of animal waste was oxidized during the running down of stream. Also, the contents of $NH_4$-N and $PO_4$-P was lower in shallow ground water with 0.1 and 0.09 mg $L^{-1}$ than those at surface water with 1.8 and 0.40 mg $L^{-1}$, respectively. Rain affected the shallow groundwater quality at stack site of animal waste. A day after rain, $NO_3$-N contents were increased very rapidly, however, contrary to the upper stream of stack which did not show any big difference with rain event. At the stack site of animal waste, the concentration of $NO_3$-N in shallow ground water showed tendency of decreasing with year, however, those at downstream was increased from 4.5 mg $L^{-1}$ in 1995 to 8.5 mg $L^{-1}$ in 2001. This implies that leaching of mineral nitrogen from animal waste affected the environmental quality at livestock farming area.

**KEY WORDS Livestock waste, nitrate nitrogen, swallow ground water, surface water**

## INTRODUCTION

Livestock waste is one of the agricultural by-products. In Korea, 34.7 X $10^6$ ton/yr of animal waste was produced in June 2000(RDA, 2001). As it contains high amounts of nutrients, livestock waste can produce environmental problems such as water pollution, bad odor, and sanitation when released into environment without any treatment (Jung, 1998). Sometime animal waste is stacked near the livestock farm in small scale. This is one of the sources of pollution in rural area. The large amounts of nutrients such as nitrogen and phosphorus from animal waste are affecting the water quality of shallow groundwater and surface water by leaching or runoff. This study was conducted to find out the effect of stacking animal waste on environment at animal farming area. To do this shallow ground water was sampled and analyzed at livestock farming area. Also, to this study aim to determine the effect of rain water on water quality, changes of inorganic nitrogen concentration in surface and shallow ground water.

## MATERIALS AND METHOD

Monitoring of shallow groundwater quality were conducted in 1995, 1997, 2000 and 2001, respectively. Water samples were collected at stack site of livestock waste and neighboring sites. Also, groundwater samples, which were used in household, were collected at monitoring area to compare the water quality with those of shallow groundwater. After the collection of samples, contents of cations and anions were determined by standard methods (APHA *et al*., 1995). The pH and EC were measured by electrometric method using Orion EA 940 ion analyzer and model 162 conductivity meter, respectively. Inorganic nitrogen such as $NH_4$-N and $NO_3$-N were analyzed by phenate method and ultraviolet spectrophotometric screening method. Other anions including phosphorus, chloride and sulfate were measured by stannous chloride, mecuricnitrate and turbidimetric method, respectively. The contents of cations were analyzed by ICP (GBC Integra XMP, Australia).

## RESULTS AND DISCUSSIONS

In Korea, the amounts of livestock wastes are increasing attributed to the recent high demands on meat . Table 1 shows the amounts of livestock wastes, discharged from livestock farming in Korea. With the kinds of livestock, cow meat took the largest portion of livestock waste until 1990s. This is followed by pig waste. There are several methods for treatment the animal waste in Korea. Around 26% of livestock waste are treated using purification facilities. Drying and soil filtration are used in large land areas. Heating and activated sludge method is likewise used, however requires large amounts of energy. Livestock waste has high amounts of nutrients for plant growth. Therefore, livestock waste can also be used as compost or liquid manure. Utilization rate has been increased from 19% in 1992 to 92% in 2000.

**Table 1. Yearly changes of the amounts of livestock wastes produced in Korea**

| Year | Meat cow | Milk cow | Pig | Poultry | Total |
|---|---|---|---|---|---|
| 1970 | 6,853 | 312 | 1,726 | 785 | 9,676 |
| 1980 | 7,253 | 2,339 | 2,735 | 1,333 | 13,659 |
| 1990 | 8,644 | 6,549 | 6,941 | 2,473 | 24,607 |
| 2000 | 8,473 | 7,065 | 12,593 | 3,919 | 32,049 |

(source : Rural Development Administration in Korea, 2002)

The water quality of shallow groundwater at livestock farming area is variable with soil characteristics, farming years and number of heads of raised livestock. Figure 1 shows the inorganic nitrogen concentration in shallow groundwater with sites. The content of ammonium nitrogen in water sample was high with 24.0 mg $L^{-1}$ in areas near the animal waste stack site. However, nitrate nitrogen was shown with high concentration of 31.8 mg $L^{-1}$ at downstream, which originates from stack site. Jordon and Smith (1985) reported that high amounts of organic nitrogen were detected at groundwater, where animal waste was dumped. This means that mineralization and nitrification of organic and ammonium nitrogen in water took place during water flows.

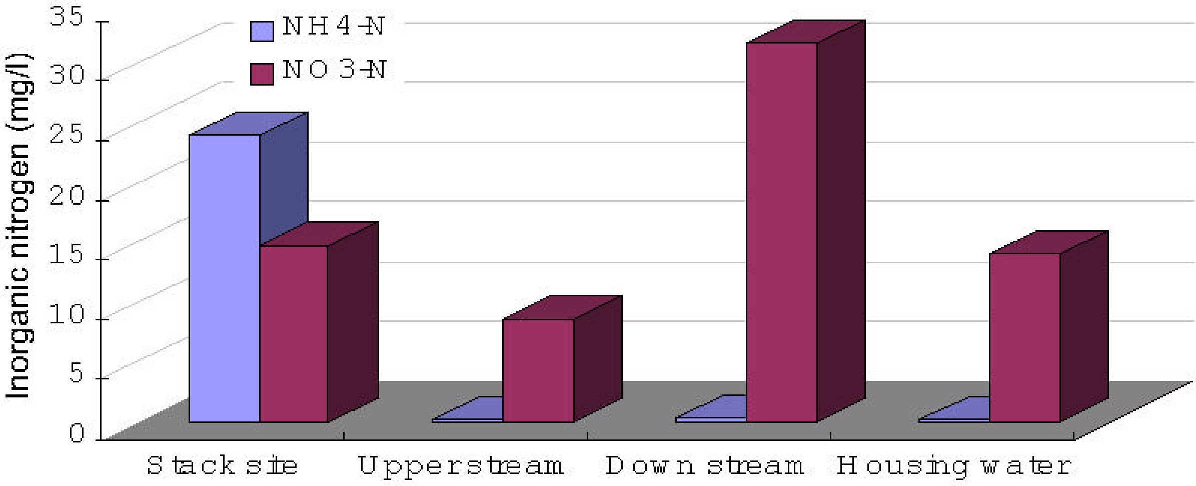


***Fig. 1.*** *Concentration of inorganic nitrogen in shallow ground water with different site.*

Table 2 shows the concentrations of major ions in surface and shallow groundwater downstream of stack site. Ammonium nitrogen and phosphorus concentrations were high with 1.79 and 0.40 mg $L^{-1}$ in surface water. On the other hand, those at shallow groundwater were 0.11 and 0.09 mg $L^{-1}$, respectively. In case of nitrate nitrogen, it was 15.03 mg $L^{-1}$ which was higher than surface water of 8.02 mg $L^{-1}$.

**Table 2. Chemical properties of surface & shallow groundwater down-stream of stack of livestock waste (unit : mg $L^{-1}$)**

| Division | $NH_4$-N | $NO_3$-N | $PO_4$-P | $SO_4$ | Cl | Ca | Cu | Fe |
|---|---|---|---|---|---|---|---|---|
| Surface water | 1.79 | 8.02 | 0.40 | 20.9 | 13.5 | 19.8 | 0.014 | 0.085 |
| Shallow groundwater | 0.11 | 15.03 | 0.09 | 39.6 | 12.9 | 32.0 | 0.005 | 0.113 |

Chemical characteristics of soil with different sites were shown in table 3. The contents of major chemical elements were relatively higher at stack site compared to upper stream site where there was no pollution source. This means that chemical properties of soil were affected with livestock waste stack. Increase of contents was higher at topsoil than subsoil. Also, copper, one of feed additive components, was seen as soil pollutant at stack site of livestock waste. In topsoil, copper content was high with 13.7 mg $L^{-1}$ at stack site compare with 0.12 mg $L^{-1}$ at down stream site.

**Table 3. Chemical properties of soil with different sites**

| **DIVISION** | | pH | EC | $P_2O_5$ | $SO_4$ | Cl | Ca | Cu |
|---|---|---|---|---|---|---|---|---|
| | | | ( $^{-1}$) | ------------------- mg $L^{-1}$ | --------------------- | | | |
| Surface soil | Stack site | 6.8 | 128.6 | 192.8 | 24.0 | 2.5 | 126.1 | 13.69 |
| | Upper-stream | 4.3 | 55.4 | 4.6 | 6.2 | 1.0 | 14.2 | 0.12 |
| | Down-stream | 5.1 | 52.8 | 24.9 | 8.3 | 1.2 | 72.4 | 0.79 |
| Sub-surface soil | Stack site | 5.9 | 134.4 | 26.5 | 13.8 | 3.2 | 59.4 | 0.80 |
| | Upper-stream | 5.0 | 14.1 | 2.1 | 5.2 | 0.8 | 26.3 | 0.05 |
| | Down-stream | 5.8 | 22.6 | 8.7 | 20.0 | 2.1 | 78.8 | 0.28 |

The yearly changes of nitrate nitrogen concentration in shallow groundwater monitored at stack site of livestock waste and neighboring sites were recorded to find out the effect of stack of livestock on water quality. The result is shown in figure 2. At stack site, it showed decreasing trend except in 2001. However, it was increased from 4.5 $L^{-1}$ in 1995, 4.8 $L^{-1}$ in 1997 to 8.5 $L^{-1}$ in 2001 at neighboring sites. This result means that pollutant diffused from stack site to neighboring areas and contamination of livestock farming area was caused by the stack of waste not properly treated.

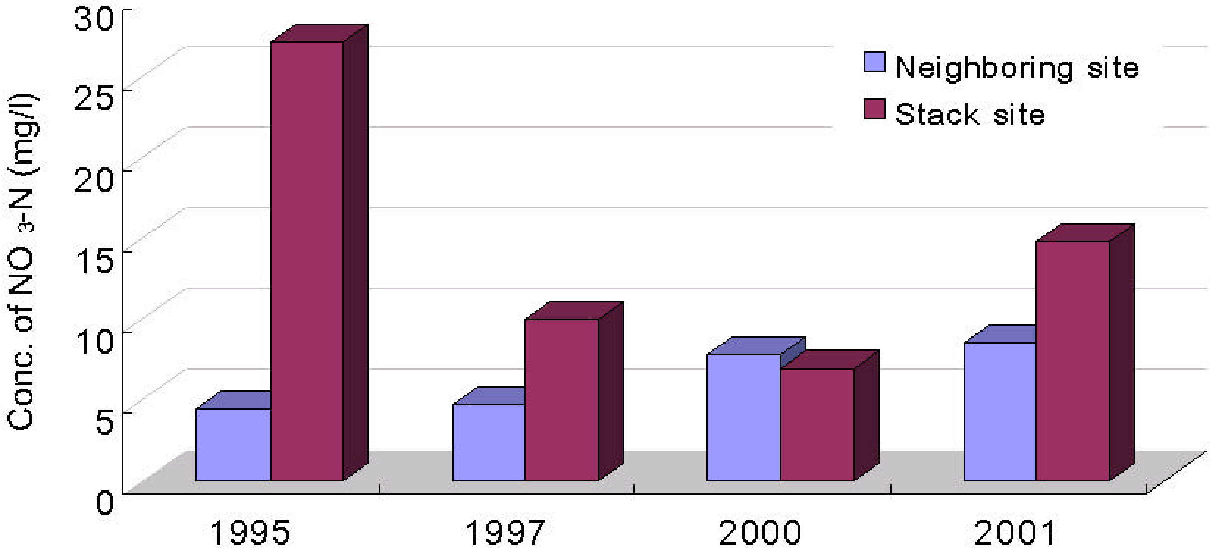


***Fig. 2.*** *Yearly changes of $NO_3$-N in shallow ground water with stack of animal waste.*

The water quality of surface water and shallow groundwater was monitored at stack site of livestock waste and neighboring sites in order to find out effect of rain on water quality at livestock farming area. Water were sampled during rain and one and three days after rain. The change of surface water quality with time was shown in Figure 3. Ammonium nitrogen concentration in upper stream did not show any difference with time. Contrary to this, the ammonium nitrogen concentration at the stack site showed a big difference, particularly days after the rain. The effect of rain was minimal at the confluence of two streams. This is due to lower flux from stack site than those from non-contaminated stream even with the former having high concentration of ammonium nitrogen. At stack site of livestock waste, ammonium nitrogen concentrations were recorded at 1.3 and 2.4 mg $L^{-1}$ at the day and one day after rain, respectively. However, it increased to 17.5 mg $L^{-1}$ three days after rain. This result indicated that dilution effect of rainwater stopped within three days after rain. Nitrate nitrogen concentration of surface water at upper stream and confluence site of streams did not show any big difference, but it was increased from 3.7 mg $L^{-1}$ at rain day to 5.9 mg $L^{-1}$ at one day after rain at down stream. This shows the dilution effect of rainwater at down stream.

The change of nitrate nitrogen concentration in shallow groundwater with time after rain is shown in Figure 4. At stack site of livestock waste, it was recorded at 5.5 mg $L^{-1}$ at the rain day due to the dilution with rainwater. However, one day after rain, nitrate nitrogen concentration was rapidly increased to 32.5 mg $L^{-1}$. This means that dilution effect of rainwater on shallow groundwater quality was decreased at one day after rain at stack. At downstream, where is away from stack site, showed 27.9, 33.7 and 34.0 mg $L^{-1}$ concentration at the day, one and three days after rain, respectively. There was also dilution effect of rainwater but it was much lower than those at stack site. The concentration of nitrate nitrogen in shallow groundwater at upper stream site where there was no pollution source, was much lower than other sites. However, it also showed an increasing tendency with time after rain 0.8 mg $L^{-1}$ at rain day to 1.6 and 1.7 mg $L^{-1}$ at one and three days after rain. Meanwhile, concentrations of nitrate nitrogen of groundwater used as household water were 9.9, 10.0 and 10.0 mg $L^{-1}$ at the day, one and three days after rain, respectively. This result did not show any difference with time after rain since household water was groundwater, which was pumped up from deep soil depth. This was not affected by infiltration of rainwater.

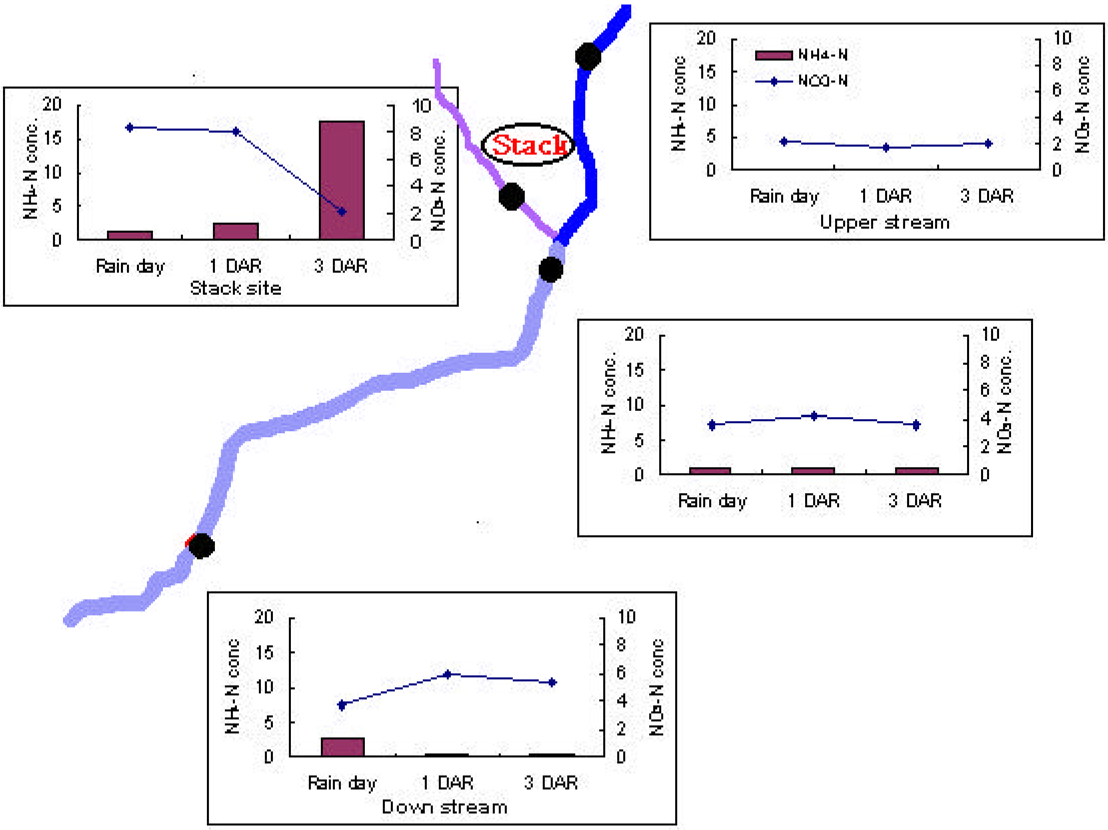


*Fig.3* *Changes of inorganic nitrogen concentration in surface water with time after rain.*

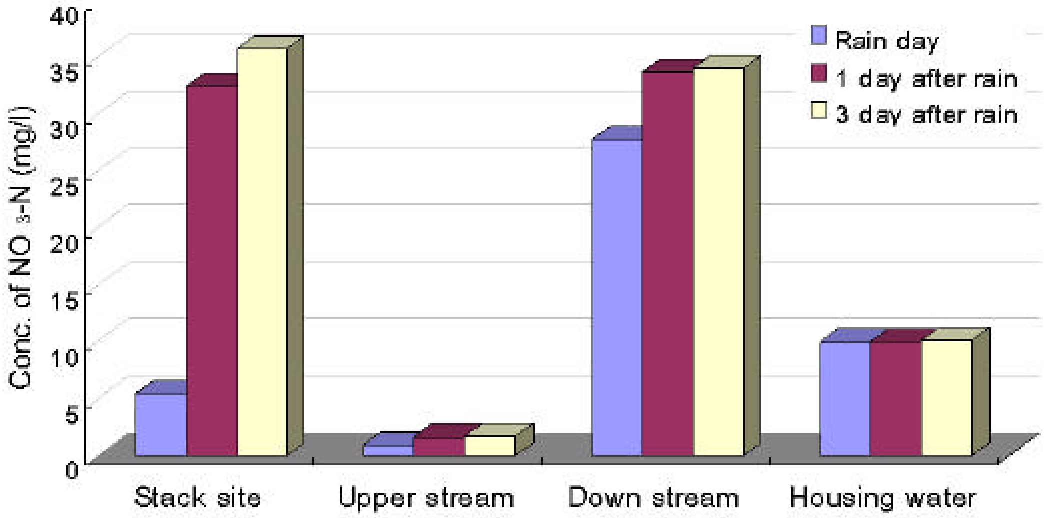


***Fig. 4.*** *Changes of $NO_3$-N concentration in shallow ground water with time after rain.*

## REFERENCE


American Public Health Association, American Water Works Association, and Water Environment Federation. 1995. Standard methods for examination of water and wastewater. American Public Health Association. p. 4-484-137.

Jordon, C and R.V. Smith. 1985. Factors affecting leaching of nutrients from an intensively managed grassland in County Antrim, Northern Ireland. J. Environ. Manage 20: 115.

Jung K. Y. 1998. The plan for activation of livestock liquid manure utilization. Symposium on environment friendly technology for animal waste treatment (Korean). p. 85,102.

Rural Development Administration, Korea. 2001. Technology for usage of livestock liquid manure(Korean). Munseongsa. p. 34.

Rural Development Administration, Korea. 2002. Technology for usage of livestock liquid manure(Korean). Sangroksa. p. 209,212.