Journal of the Korean Society of Grassland and Forage Science 38(4): 349~356, 2018
https://doi.org/10.5333/KGFS.2018.38.4.349 ISSN 2287-5824 (Print)
ISSN 2287-5832 (Online)

Research Article

Effect of Goat Grazing on Surface Water Quality of Alpine Grassland

Ali Sultan Khan, Jeong-Tae Kim, Dong-Woo Kim, Ha-Young Park and Chan-Ho Kwon*
Kyungpook National University, Sang-ju 37224, Republic of Korea

ABSTRACT

The objective of this study was to determine the effect of goat grazing on the surface water quality of the alpine grasslands. Seven sites were selected across the goat farm for water sample collection and analysis. Samples were analyzed for BOD (Biological oxygen demand), total nitrogen, total phosphorous, electrical conductivity and water turbidity. All the above-mentioned parameters remained below the standard limit of Korean government at the end site. Puddles showed higher values, but below standard, as stagnant water has lower physico-chemical properties as of flowing water. The present study clearly showed that goat grazing doesn't affect water quality in grasslands if grazing is according to carrying capacity of grassland and fertilizer application is judicious.
(**Key words**: water quality, grazing, goat)

Ⅰ. INTRODUCTION

Grasslands are playing an important role in agricultural development by securing man's food supply to areas where crops and animals cannot survive due to the scarcity of food, especially in cold, temperate and mountainous areas of the world. Food and Agriculture Organization (FAO) reports that meadows and pastures cover 3.4 billion ha agricultural area of the world, simply putting they cover 69% of the world's agricultural area. According to global land area classification by ecosystem type (Loveland et al., 2000) aggregate of the open or close shrublands, Woody, and non-woody savannas, and Grasslands is estimated to cover 50 million square kilometers or 37% of the earth's habitable area. In the Asia-Pacific region, forest and grasslands cover 57.5 percent (2,008.9 million hectares) of the land surface (FAO, 2013) and provide to support agriculture, food security, and nutrition. Moreover, these lands also offer huge contribution potential for climate change adaptation by contributing to community resilience, livelihoods and poverty alleviation, and capturing huge benefits of carbon sequestration.

Korean peninsula comprises 221,000 km^2, 45 % of which makes up the Republic of Korea(ROK). Approximately 30% of ROK consists of the lowlands, with rest consisting of uplands and mountains. Only 20% of the total land area in the ROK is used for agriculture and forests cover 64% of the total area (KFS, 2010). Korean peninsula lies to the east of the temperate forest zone, which contributes to the distinct seasonal temperature and precipitation. As of 2011, only 15.3 % of the total area of ROK is arable land and 2.2, 6.6 % of the area is under permanent crops and permanent pasture, respectively (J.S. Bae et al., 2012). Due to above-mentioned land use statistics and changing food priorities, it is evident that grasslands and mountainous areas must have to be used for agricultural production i.e. crop production, grazing rangelands, wood production and other forest products.

Water is an important factor in the use of land. Grasslands are critically important water production landscapes, playing a vital role in maintaining the quality and quantity of water entering rivers, streams and recharging the underground water table and aquifers. The nature of the herbaceous vegetation in the grasslands forms an effective substrate for capturing water, increasing infiltration, checking erosive run-off and reducing soil loss. This way, these ecosystems play a role in augmenting and regulating stream flow by holding water in the soil profile, or within wetlands, and slowly releasing it into rivers and water bodies. Increasing the grassland for forage crops results in substantially improved water quality (Ball et al., 2002).

Livestock grazing on the pastures with special emphasis on avoiding overgrazing as that of the carrying capacity leads to much lower nutrient contamination of the water than that of the heavily fertilized conventional crops. Organic components of

*Correspondingauthor: Chan-Ho Kwon, Kyungpook National University, Sang-ju 37224, Republic of Korea
Tel: +82-54-530-1226, Fax: +82-54-530-1226, E-mail: chkwon@knu.ac.kr

feces and urine from grazing animals improve the organic matter content of the soil resulting in the higher water holding capacity, increased water-infiltration rates, and improved soil stability.

Although grasslands limit the sediment, nutrient, and pathogen loading of the water resources (Gyssels et al., 2005), it may degrade the water quality of the streams, lakes, or other water bodies by excessive amounts of dissolved or suspended sediment in surface run-off. Many studies have reported sediment concentrations and load more than the allowable limit (Griffiths, 1982; Neff, 1982; Carling, 1983). Total nitrogen in the water above 10 mg/L causes methemoglobinemia and infants are more susceptible. Numerous studies have reported nitrogen concentration above 10 mg/L in groundwater because of agricultural activities comprising cropping operations, livestock, and grazing (Hubbard et al., 1987; Naney et al., 1987; Sharpely et al., 1987). Apart from nitrogen, phosphorous is also of environmental concern as the excess amount of that in water causes eutrophication. Phosphorous contribution from animal grazing in barnyards or pastures close to the stream also contributes to the higher concentration of phosphorous in the soil. As organic matter serves as energy source for bacteria, manure from grazing animals can also serve as oxygen demanding material hence, increasing the oxygen demand of the water streams (Hatfield et al., 1998).

Globally there is a lot of literature available showing the impacts of grazing in the grasslands on the surface water quality and water channels in the grasslands. As Love (1958) wrote, "There is a large body of information leading to the conclusion that heavy grazing has had bad hydrologic consequences". Unfortunately, in Korea, there is no significant study carried out to check the impact of grassland grazing on the water quality parameters.

This study was carried out to determine the effect of seasonal goat grazing on the chemical and microbial characteristics of surface water in a grassland in the Gimcheon-si Gyeongsangbuk-do province of ROK.

Ⅱ. MATERIALS AND METHODS

1. Grazing site

This study was undertaken at the Chupungnyeong area located in Gimcheon-si, Gyeongsangbuk-do province of ROK (36.2133°N, 127.9963°W). Three large fields for grazing was selected serving as sampling sites: Site 1 being present at the beginning outside of the farm, Site 2 being present in the middle of the field and site 3 was present at the end of the field. Run-off water flows from Control to site 1, then into site 2 and site 3 and then drains out of the end zone to form natural stream. Puddles were fed by excess or over-flowing water during rainy season, having no definite water source.

Fig. 1 Map of goat grazing farm

2. Sampling frequency

Water samples were collected from the treatments and puddles on last Friday of grazing period i.e. April to October, depending on the availability of the water sample due to varying precipitation during whole the experimental study period i.e. April to October.

Samples were collected in 2L water sample bottles and then transported to the laboratory for analysis.

Grazing species and intensity

During the grazing period i.e. April to October 2017 & 2018, 200 Bore goats (*Capra hircus)* were rotationally grazed at 5 fields for 3-5 days after every 3-4 weeks over an area of 18,949 m^2.

3. Weather conditions

Weather data of Chupungnyeong was obtained from Korea Meteorological Administration.

4. Total nitrogen

Sample Preparation

50 ml. of water sample was taken in a syringe bottle, then 10 mL alkaline $K_2S_2O_8$ is added and closed with stopper. Syringe bottle is shake and heated in high- pressure steam sterilizer for 30 minutes at ~120°C. Then sample is cooled and stored for further analysis.

Analysis Procedure:

Nitrogen present in water samples was determined by UV/Visible line spectroscopy-Oxidation method of American Public Health Association (APWA, AWWA, WEF, 1998). Briefly, 25ml of pre-treated sample is filtered with glass fiber filter paper, 25 ml of the filtrate is taken into a beaker and 5 mL of HCl is added to adjust pH to 2~3. A portion of this solution is transferred to 10 mm strand absorption cell to prepare sample solution. At other hand, 50 mL of purified water is prepared to be used as base test solution. Then absorbance of the sample solution is measured at 220 nm. Then a calibration curve is prepared to determine absorbance of test Solution.

Absorbance of the test solution is converted to total nitrogen by following Equation:

$$\textbf{Total nitrogen}\ (mg/L) = a \times v \qquad (Eq.1)$$

Where, "a" is the Value of test solution for calibration curve, "v" is the amount of sample used in preparation.

5. Biological oxygen demand (BOD)

Sample Preparation

pH of the sample was adjusted in the range of 7 to 7.2 by neutralizing the sample with HCL or NaOH Solutions (1M).

Analysis Procedure

Biological oxygen demand (BOD) is determined following the method of US Environmental Protection Agency (US EPA Method, 1974).

Briefly, Sample was diluted 1~5% and filled in 2-L volume cylinder with half the amount of air. Then bottle was filled with dilution water and stopper was placed at each bottle with no air trapped inside the bottles. Then BOD was determined by the dissolved oxygen measurement method after 15 minutes from one bottle and other bottle was incubated for 5 days at 20°C. After 5 days of incubation, dissolved oxygen was measured form the incubated sample. BOD was estimated by following equation:

Table 1. Weather condition of Chupungnyeong, Republic of Korea from April to October, normal years (1987~2016)

Factor	Year	Month						
		April	May	June	July	August	September	October
Mean temperature (°C)	Normal years	11.5	17.3	21.1	23.9	24.4	19.3	13.5
	2017	13.4	18.1	21.5	25.2	24.0	18.8	13.7
	2018	12.7	17.3	21.6	25.9	26.3	19.0	-
Accumulated precipitation (mm)	Normal years	79.3	76.4	108.3	265.9	233.9	129.5	57.2
	2017	64.7	21.3	60.6	273.4	208.2	105.9	48.2
	2018	132.0	81.1	89.6	123.8	335.4	92.4	-

Source: Korea Meteorological Administration

$$\textbf{BOD (mg/ L)} = (D1 - D2) \times P \qquad \textbf{(Eq. 2)}$$

Where, "D1" is dissolved oxygen of diluted sample after 15 minutes; "D2" is dissolved oxygen of diluted sample after 5 days of incubation, "P" is dilution ratio of the sample in the diluted sample (Diluted sample amount/ sample amount).

6. Total phosphorous

Sample Preparation

50 mL of the sample was taken in a syringe bottle and 4% 10 mL $K_2S_2O_8$ was added before closing the cap. Then the sample was mixed and heated in a high-pressure steam sterilizer for 30 minutes at ~120°C. Then sample was cooled down and stored for analysis.

Analysis Procedure

Total phosphorous was measured by UV/ Visible spectrometry method (US EPA, 1993; APHA, AWWA, WEF, 2005). Briefly, 25 mL of the pretreated sample was taken in a test tube with stopper and 2 mL ammonium molybdate/ ascorbic acid mixed solution was added, sample was shaken and allow to stand for 15 minutes at 20-40°C. Portion of this solution was transferred to 10 nm absorbance cell. At other hand, 50 mL of pure water was also subjected to sample test procedure. Absorbance of the sample was measured at 880 nm and calibration curve was prepared according to the relationship between amount of phosphorous and absorbance. Total phosphorous was calculated from following equation;

$$\textbf{Total phosphorous (mg/L)} = a \times \frac{60}{25} \times \frac{1000}{50}$$

7. Electrical conductivity

Electrical conductivity was measured following a standard protocol (US EPA, 1982; APHA, AWWA, WEF, 2005). Accordingly, the conductivity cells were washed with pure water two to three times before washing the cells with 0.01 M potassium chloride solution 2-3 times. Electrical conductivity was measured with cells immersed in potassium chloride solution at room temperature i.e., 25°C. This procedure was repeated 2-3 times and mean value was calculated for estimating Cell constant by following equation:

$$\textbf{Cell constant} \ \frac{L_{KCL} + l_{H2O}}{L_X}$$

Where, "L_x" is mean conductivity value (μS / cm)

L_{KCl}: Conductivity value (μS / cm) of the standard potassium chloride solution used

L_{H2O}: Conductivity value (μS / cm) of water used in preparing the potassium chloride solution.

Analysis Procedure

Cells were washed with sample, then cells were immersed in the sample and temperature was maintained at 25°C. Electrical conductivity was measured repeatedly, mean value was calculated and EC was estimated according to following formula:

$$\textbf{Electrical conductivity (μS/ cm)} = C \times L_X \qquad \textbf{(Equation 1)}$$

Where, "C" is the cell constant;
"L_x" is measured Electrical Conductivity Value (μS).

8. Water turbidity

Water turbidity was measured by using the standard protocol of US Environmental Protection Agency (US EPA 1993). According to that, samples were maintained at room temperature before analysis and then mixed thoroughly for uniform dispersion of solids. After the bubbles disappeared from the surface, the sample was transferred to the turbidity-meter tube (Turbidity Meter, Lamotte, Model 2008, USA). Reading on the meter was recorded as nephelometric turbidity units (NTU's).

9. Korean standard of effluent from livestock farm

Table 2. Korean standard of effluent from livestock farm

	Standard of wastewater from livestock farm		Environmental standard for water quality		
	Effluent to general area	Effluent to special area[1)]	Effluent to public facility	River	Laguna
BOD(mg/L)	≦120	≦40	≦30	≦3	-
Total nitrogen(mg/L)	≦250	≦120	≦60	-	≦0.03
Total phosphorous(mg/L)	≦100	≦40	≦8	≦0.1	≦0.4

[1)]Drinking source

Source: Law for the preservation of water quality

Ⅲ. RESULT AND DISCUSSION

At the end of April 2017, the BOD (Biological oxygen demand) remained well below the standard limit by the Korean government i.e. 30mg/l at all the sites. Puddle 1 recorded the highest BOD i.e. 5.1 followed by puddle 2 i.e. 4.6 mg/l. BOD showed the same trend at the end of May 2017, where puddle 2 showed 8.8 mg/l followed by puddle 1 i.e. 4.4 mg/l. And succeeding at the end of June 2017, BOD followed same trend as the preceding months being highest in Puddle 2 i.e. 18.7 mg/l followed by puddle 1 i.e. 14.3 mg/l. At the end of July 2017, site 1 showed the highest BOD i.e. 14.9 mg/l followed by site 2 i.e. 11.7 mg/l and the site of main concern i.e. end site showed 9.2 mg/l, which was falling under the standard limit of ≤30 mg/l. At the end of August 2017, Puddle 1 and 2 showed the same trend as the preceding months, being highest in puddle 2 i.e. 6.3 mg/l followed by puddle 1 i.e. 5.1 mg/l and the end site showed 1.6 mg/l that was well below the standard limit. At the end of September 2017 the trend shifted a little where site 2 showed the highest BOD i.e. 9.7 mg/l followed by site 1 i.e. 5.9 mg/l while end site showed 1.6 mg/l, being well below the limit. At the end of October 2017, BOD followed the same trend being highest in site 1 i.e. 17.2 mg/l followed by site 3 i.e. 14.6 mg/l, where end site showed 1.4 mg/l, being well below the limit.

At the end of April 2018, BOD was almost same at the all sites and well below the limit. Same trend was carried forward at the end of the May and June 2018. At the end of July 2018, puddle 2 showed 7.8 mg/l followed by 1 i.e. 7.0 mg/l. At the end of August 2018 also showed same trend i.e. highest in the puddle 1 i.e. 6.6 mg/l. similarly, At the end of September 2018 also showed same trend where BOD was highest in puddle 1 i.e. 6.0 mg/l.

At the end of April, May and June, total nitrogen followed same trend and was in negligible amount at all sites. At the end of July 2017, site 1 showed highest value i.e. 16.2 mg/l, being well below the standard limit i.e. ≤ 60mg/l. At the end of August, all sites showed almost negligible total nitrogen. At the end of September and October, it followed same trend being highest in site 1 i.e. 252 mg/l because of fertilization. But it remained well below the standard limit at the end zone, which is water outlet to water bodies.

At the end of April, May and June 2018, total nitrogen showed same trend at all sites as that of preceding year i.e. almost negligible at all sites. At the end of July and August 2018, Puddle1 showed the highest total nitrogen i.e. 6.0 mg/l.

At the end of April, May and June 2017, total phosphorous was almost negligible at each site. At the end of July 2017, it increased in site 1 i.e. up to 0.737. At the end of August and September 2017, it followed same trend and was

Table 3. BOD (Biological oxygen demand) variation due to grazing across the goat farm during April- October 2017 and April-September 2018.

BOD (mg/L)		Control	Site 1	Site 2	Site 3	End	Puddle 1	Puddle 2
2017	April	0.9	0.6	0.9	1.1	1.0	5.1	4.6
	May	-[1)]	-[1)]	-[1)]	-[1)]	-[1)]	4.4	8.8
	June	-[1)]	-[1)]	-[1)]	-[1)]	-[1)]	14.3	18.7
	July	-[1)]	14.9	11.7	4.0	9.2	3.5	7.8
	August	1.8	2.0	1.6	2.4	1.6	5.1	6.3
	September	2.4	5.9	9.7	1.6	1.6	5.1	3.0
	October	2.2	17.2	13.1	14.6	1.4	3.2	2.7
2018	April	1.1	1.1	1.1			2.0	-
	May	0.9	1.3	0.3			2.3	-
	June	0.1	1.0	1.2			5.1	-
	July						7.0	7.8
	August	1.8	1.8			2.0	6.6	
	September	0.1	1.4			0.8	6.0	

[1)]Samples cannot collected due to dry weather

Table 4. Variation in the total nitrogen due to grazing across the goat farm during April- October 2017 and April-September 2018.

Total nitrogen (mg/L)		Control	Site 1	Site 2	Site 3	End	Puddle 1	Puddle 2
2017	April	1.1	0.2	0.3	0.4	0.2	1.0	8.0
	May	-[1]	-[1]	-[1]	-[1]	-[1]	0.5	1.6
	June	-[1]	-[1]	-[1]	-[1]	-[1]	0.9	1.7
	July	-[1]	16.2	4.0	1.2	4.1	0.5	1.5
	August	0.6	0.6	0.5	0.8	0.5	1.0	2.1
	September	1.8	6.4	6.3	0.6	0.3	1.1	0.9
	October	0.6	252.0	55.0	77.4	0.2	0.3	0.5
2018	April	0.6	0.3	-		0.9	0.8	-
	May	0.3	2.1	-		0.7	0.8	-
	June	0.1	1.0	-		1.2	5.1	-
	July	0.9	0.9			0.8	6.0	
	August	1.5	1.6			1.8	6.6	
	September	0.9	0.9			1.1	1.1	

[1]Samples cannot collected due to dry weather

Table 5. Variation in the total phosphorous due to grazing across the goat farm during April- October 2017 and April-September 2018.

Total phosphorus (mg/L)		Control	Site 1	Site 2	Site 3	End	Puddle1	Puddle2
2017	April	0.016	0.007	0.016	0.032	0.021	0.084	0.088
	May	-[1]	-[1]	-[1]	-[1]	-[1]	0.049	0.220
	June	-[1]	-[1]	-[1]	-[1]	-[1]	0.093	0.190
	July	-[1]	0.737	0.167	0.165	0.335	0.043	0.177
	August	0.011	0.016	0.011	0.077	0.019	0.081	0.192
	September	0.172	0.110	0.087	0.062	0.021	0.106	0.078
	October	0.056	None[2]	1.120	4.130	0.030	0.042	0.044
2018	April	0.062	0.011	-		0.011	0.079	-
	May	0.035	0.108	-		0.005	0.129	-
	June	0.010	0.042	-		0.044	0.213	-
	July						0.552	0.228
	August	0.055	0.154			0.169	0.185	
	September	0.035	0.109			0.113	0.129	

[1]Samples cannot collected due to dry weather
[2]Cannot measure due to large variation

negligible at each site. At the end of October 2017, site 3 showed a little higher total phosphorous i.e. 4.13 mg/l because of fertilization.

At the end of April, May and June 2018, it showed almost negligible reading at each site. At the end of July 2018, Puddle 1 showed highest total phosphorous i.e. 0.552 mg/l and in succeeding months it was again negligible at each site.

At the end of April, May and June 2017, electrical conductivity also showed same trend being highest at Puddle 1 and 2. At the end of July 2017, Puddle 1 and site3 showed the highest electrical conductivity i.e. 140 and 138 μs/m respectively. At the end of August and September 2017, puddle 1 and 2 showed the highest values i.e. 113 and 106 μs/cm respectively at the end of August and 134 and 101 us/cm respectively in September. At the end of October 2017, electrical conductivity increased at all sites except puddle 2 and control.

At the end of April 2018, puddle 1 showed the highest electrical conductivity. At the end of May 2018, site 1 and control showed the highest electrical conductivity i.e. 110 and 105 μs/cm, respectively. At the end of June, July, August and September 2018, puddle 1 showed the highest electrical conductivity in all the months.

Table 6. Variation in electrical conductivity due to grazing across the goat farm during April- October 2017 and April-September 2018.

Electrical conductivity(μS/cm)		Control	Site 1	Site 2	Site 3	End	Puddle1	Puddle2
	April	48	53	56	68	80	99	95
	May	-[1)]	-[1)]	-[1)]	-[1)]	-[1)]	111	104
	June	-[1)]	-[1)]	-[1)]	-[1)]	-[1)]	120	104
2017	July	-[1)]	110	97	138	111	140	102
	August	46	56	59	85	80	113	106
	September	52	82	84	99	98	134	101
	October	49	208	110	164	106	142	99
	April	49	58			59	97	
	May	105	110			38	104	
2018	June	45	69			70	91	
	July						104	96
	August	43	58			59	79	
	September	44	72			66	73	

[1)]Samples cannot collected due to dry weather

Table 7. Variation water Turbidity due to grazing across the goat farm during April- October 2017 and April-September 2018.

Water turbidity (NTU)		Control	Site 1	Site 2	Site 3	End	Puddle1	Puddle2
	April	3.8	1.2	3.1	8.4	2.5	21.4	4.5
	May	-[1)]	-[1)]	-[1)]	-[1)]	-[1)]	16.9	12.7
	June	-[1)]	-[1)]	-[1)]	-[1)]	-[1)]	14.0	8.2
2017	July	-[1)]	811.0	315.0	109.0	271.0	7.7	10.9
	August	2.8	4.5	2.7	17.3	3.6	9.7	20.5
	September	99.4	156.0	342.0	11.0	5.8	21.7	11.0
	October	7.7	9470.0	2440.0	3100.0	8.0	10.6	10.0
	April	14.1	1.2			2.2	5.6	
	May	6.0	30.3			1.1	7.5	
2018	June	3.6	11.8			16.1	25.5	
	July						25.8	12.3
	August	41.4	51.6			59.5	28.8	
	September	9.2	31.6			31.8	18.0	

[1)0]Samples cannot collected due to dry weather

This parameter showed same trend at the end of April, May and June 2017, being highest in puddle 1. At the end of July 2017, site 1 and site 2 showed the highest turbidity. At the end of August, it was same at every site. At the end of September 2017, site 2 and 1 showed the highest water turbidity. At the end of October 2017, site 1, 2 and 3 showed the highest water turbidity, respectively as that was grazing period.

At the end of April, May, June and July 2018, it was same at every site and negligible. At the end of august 2018, end and site 1 showed the highest water turbidity and At the end of September 2018, it decreased to almost negligible value.

Conclusion

Seasonal goat grazing at moderate stocking rates in open alpine grasslands bisected by rain & runoff fed streams contributed some effluents to the stream, but that contribution was well below the standard limit of effluents being enforced by Government of Korea. The measured physical, chemical and microbial parameters of surface water indicated minor, local influence on water quality during the grazing period. Based on our study having moderate stocking rates and better grazing practices, permanent removal of grazing animals from the grasslands does not seem justified now for water quality maintenance.

Moreover, our study can provide a scientific reference for the local land use optimization and pollution control and assist the formulation of policies for coordinating the water resource exploitation and protection.

Furthermore, Water quality is related to variety of factors related a variety of factors such as climate, precipitation and landscape management. So there is a need to refine the method and indicators to deeply reveal the reasons causing water quality change.

Ⅳ. ACKNOWLEDGEMENTS

This work was carried out with the support of “Cooperative Research Program for Agriculture Science & Technology Development (Project No. PJ012592022018)” Rural Development Administration, Republic of Korea.

Ⅴ. REFERENCES

APHA, AWWA, WEF, Standard Methods for Examination of Water and Wastewater. 21th (2005)

Bae, J.S., Joo, R.W. and Kim, Y.S. 2012. Forest transition in South Korea: Reality, path and drivers. Land Use Policy. 29:198-207.

Ball, D.M., Hoveland, C.S. and Lacefield, G.D. 2002. Southern forages. Potash and Phosphate Inst. And the Foundation for Agronomic Res., Norcross, GA.

Carling, P.A. 1983. Threshold of coarse sediment transport in broad and narrow natural streams. Earth Surface Processes Landforms. 8:1-18.

DIN EN-1, 2, “Determination of Biochemical Oxygen Demand of Water after Days”, (2005)

FAO. 2013. FAOSTAT database. http://faostat.fao.org/site/291/default.aspx.

Griffiths, G.A. 1982. Spatial and temporal variability in suspended sediment yields of North Island basins, New Zealand. Water Resource Bull. 18:575-584.

Gyssels, G., Poesen, J., Bochet, E. and Li, Y. 2005. Impact of plant roots on the resistance of soils to erosion by water: a review. Progress in Physical Geography. 29:189-217.

Hubbard, R.K., Thomas, D.L., Leonard, R.A. and Butler, J.L. 1987. Surface runoff and shallow groundwater quality as affected by center pivot applied dairy cattle wastes. Trans. Am. Soc. Ag. Eng. 30:430-437.

JIS K 0400-21-10, “BOD5”, Japan Standards Association, (2005)

Korea Forest Service, 2013, Korean forests at a glance.

Love, L.D. 1958. Rangeland watershed management. Pages 198-200 in Proc. Soc. Foresters, Salt Lake City, UT

Loveland, T.R., Reed, B.C., Brown, J.F., Ohlen, D.O., Zhu, Z., Yang, L. and Merchant, J.W. 2000. Development of a global land cover characteristics database and IGBP DISCover from 1-km AVHRR Data. International Journal of Remote Sensing. 21:1303-1330.

Naney, J.W., Kent, D.C., Smith, S.J. and Webb, B.B. 1987. Variability of ground-water quality under sloping agricultural watersheds in Oklahoma. In Proc. Symp. on Monitoring, Modeling, and Mediating Water Q7uality. Am. Water Resources Assoc., Bethesda, MD.

Neff, E.L. 1982. Chemical quality and sediment content of runoff water from southeastern Montana rangeland. J. Range Manage. 35:130-132.

Rim-Rukeh, A. 2013. Physico-chemical and biological characteristics of stagnant surface water bodies (Ponds and Lakes) used for drinking and domestic purposes in Niger Delta, Nigeria. J. Env. Protection. 4:920-928.

Sharpley, A.N., Smith, S.J. and Naney, J.W. 1987. Environmental impact of agricultural N and phosphorus use. J. Agric. Food Chem. 35:812-817.

US EPA 120.1, “Specific Conductance (UMhos at 25°C)”, EPA, (1982)

US EPA 841-B-97-003, & quot; Volunteer Stream Monitoring: A Methods Manual. & Quot; EPA, (1997)

US EPA Method 405.1, “Biochemical Oxygen Demand (5 days, 20°C)”, EPA, (1974)

(Received : November 1, 2018 | Revised : November 22, 2018 | Accepted : November 22, 2018)