IMPACTS OF DIFFERENT FOREST WATERSHED COMPOSITION FACTORS ON SOIL CONDITION IN UPSTREAM OF MIYUN RESERVOIR WATERSHED AND ITS CURRENT SITUATION

by

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APRIL 30th, 2020

Impacts of Different Forest Watershed Composition Factors on Soil Condition in Upstream of Miyun Reservoir Watershed, Northern China and Its Current Situation

By

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An Undergraduate Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Honours Bachelor of Science in Forestry

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April 30th, 2019

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ABSTRACT

Lang, X. 2019. Impacts of Different Forest Watershed Composition Factors on Soil Condition in Upstream of Miyun Reservoir Watershed, Nothern China and Its Current Situation

Keyword: soil condition, Miyun Reservoir Watershed, sustainable development, watershed management

This thesis explores the Miyun Reservoir Watershed's soil condition and the current situation it faces now. Miyun Reservoir is located in northern Beijing and has more than sixty years of history. It is the primary water source in Beijing and was listed as a first-grade water source protection in 1985. The reservoir has a maximum surface area of 188 square kilometers, and it is shaped like an equilateral triangle. For a better sustainable development, the government and each department began to plan and survey Miyun Reservoir in 1951. Nowadays, the scale of watershed treatment development is getting bigger and bigger, and this place has received more and more attention. By doing literature reviews and analysis from the database, this thesis discusses the factors that affect the soil condition changes in various watershed compositions, such as land-use types, soil properties, soil organic matters, topography, and water areas. Different components can affect soil moisture, chemical elements in soil, and the degree of soil erosion from all aspects. At the same time, it also faces the pollution problems, which leads to a decrease in water quality and balance of the ecosystem there. More policies are implemented in the Miyun Reservoir, and it becomes more and more important for better environmental protection and tourism development.

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ACKNOWLEDGEMENTS

I want to show my deepest gratitude to my supervisor Dr. Jian R. Wang, and my second reader Dr. Kevin A. Crowe. They are respectable and responsible, and they have provided me with valuable guidance in every stage of this thesis. Without their enlightening instruction, extraordinary kindness and patience, I could not have completed my thesis.

1. INTRODUCTION

The Miyun Reservoir Watershed (MRW) is located in Miyun District, Beijing, China, and it was built in September 1960, which is a mountain valley reservoir. Miyun Reservoir, with a capacity of 4 billion m^3 and an average water depth of 30 meters, which is the largest and only source of drinking water of Beijing. It is a large comprehensive water conservancy project with the main functions of flood control, power generation and urban water supply. MRW has two major inflow rivers, which are the Bai He River and the Chao River. On November 19th, 2017, Miyun Reservoir's water storage capacity exceeded 2 billion m^3, which becomes the largest storage capacity of water since the 21st century. The purpose of this thesis is to examine changes in soil conditions in MRW and discuss external causes and internal causes that affect the soil within the watershed and the MRW current situation.

From now on, the main artificial structures in MRW have two main dams, five auxiliary dams, two water tunnels, three large spillways, two power stations, one sizeable regulating tank and one Miyun to Beijing water diversion canal. In the 30 years after the completion of the MRW, huge benefits have been generated in flood control, irrigation, the supply of urban water, power generation, fish farming, and tourism. The direct economic benefits as of 1990 are equivalent to six times the total investment in the reservoir. With the development and reinforcement of MRW, many environmental problems have come up. Water soil erosion is one of the difficult situations we need to face. To improve the investment climate, we must focus on its protection. I researched the soil types and some that may influence soil conditions and subarea, data collection and comparative analysis to study soil conditions in MRW. The current situation that MRW faces is its environmental problem. Because MRW is at a low water level for a long time, a large area of bottomlands is formed around it. The fluidity of waterbody in the reservoir area is very poor, and its self-purification ability is reduced. There is a certain degree of eutrophication risk. With the influence of the South-to-North Water Transfer Project, a large area of inundation zone was formed. The water quality of the reservoir is the most significant factor that affects its soil, and some heavy metal elements, forest vegetation and biomass, topography, climate changes and some surrounding modern constructions also have indirect influences on MRW. The upriver of MRW may now face serious pollution problems because there are many gold mines areas and other factories upstream. At the same time, soil organic carbon and total nitrogen contents and their relationships with site characteristics are of profound importance in assessing current regional, continental and global soil C and N stocks and potentials for C sequestration and N conservation to offset anthropogenic emissions of greenhouse gases (Wang et al, 2012). Land-use for vegetation and biomass may be the dominant factor that affects soil's C and N stocks. GIS and database analysis is significant for studying soil conditions in MRW.

In summary, different vegetation coverage and soil management measures under various land-use conditions lead to the significant difference between soil nitrogen and soil organic carbon. The conversion of land-use types by humans often causes many changes in soil conditions. When forests or grasslands are turned into farmland for agricultural use, change begins. Various environmental factors and water qualities have different degrees of influence on soil pH balance, corrosion, erosion sensitivity and trace elements. For a better sustainable development in the Miyun area, it is necessary to research its environment and present situation.

1.1 OBJECTIVES

This thesis researches are based on Miyun Reservoir Watershed. The purposes of this thesis are to (1) investigate the soil condition, and current environmental situation, (2) identify main reasons causing water and soil erosion, (3) establish quantitative relationships between soil and external and internal factors (including chemical elements, biomass and vegetation, water quality and quantity, watershed-scale and land-uses, climate change.), (4) formulate and propose solutions to various severe problems for better development in Miyun Reservoir Watershed, Beijing, China.

1.2 HYPOTHESIS

If the type of land-use changes from reducing farmland area to increasing forest area, the SOC (soil organic carbon) of the upstream in MRW will gradually increase. By considering variables such as precipitation and temperature, if the reasonable control of gold mining factories in the upper basin is strengthened, then the heavy metal pollution of the soil will gradually decrease, and the level of soil erosion will also decline.

2. LITERATURE REVIEW

2.1 MANAGEMENT SYSTEMS AND POLICIES IN MIYUN RESERVOIR WATERSHED

As one of the essential sources of water resources in Beijing, MRW has attracted extensive attention to its protection and management. The government always describe that “Beijing has always protected important drinking water sources such as Miyun Reservoir like protecting our eyes.” According to the data analysis at the end of 2017 from Beijing News, the MRW has a water storage capacity of 2 billion cubic meters, and the original trees on the shore have been inundated. Among the five municipal-level surface drinking water sources in Beijing, MRW is the only one that meets the standard for water supply. Since the completion of the MRW, the management project has been more formal, and the *Miyun Reservoir Engineering Management Regulations* formed according to industry norms have been revised several times. Since the 1990s, the government has vigorously strengthened the institutionalization of management work and has formed a complete set of full complete and applicable rules and regulations. The standardization of management work has been greatly improved, as well as the modernization of management work has been comprehensively planned and gradually realized.

The central management systems in MRW are engineering observation, hydrological testing and water quality testing. In recent years, the two main challenges in the MRW now are the prevention and control of environmental pollution and degraded forest restoration and management planning. According to the project implemented by the Beijing Landscaping Bureau, which is this project supervision agency, provided with the overall goal of the project is to improve the environmental quality of MRW by carrying out sustainable management of watershed forests. The Beijing Municipal People's Government issued the Interim Measures for the Protection and Management of the Water Sources of MRW, Huairou Reservoir and Jingmi Diversion Canal in Beijing, which put some specific objectives for protecting the MRW. This policy includes improving the watershed capacity of forests in the demonstration sites through near-natural forest management methods, reducing the number of chemical fertilizers in the orchards in the upper MRW, thereby reducing water sources pollution and improving the local community livelihoods through the establishment of demonstration sites for forest culture and ecotourism and recreation projects.

2.2 BACKGROUND AND HISTORY

After 1949, the Central Government of the People's Republic of China began construction of the MRW after September 1st, 1958, due to the need for strategic water reserve and river water control. At the beginning of the construction of the MRW, the Miyun Reservoir was divided into two batches and sent to 65 different villages in the reservoir area for clean-up, to ensure installation there and to intercept flooding. In less than nine months, more than 50,000 people were relocated and resettled. In the 1970s, the MRW has a water storage level of 153 meters, which is the highest water level since the completion of the reservoir. Because some sites below 157.5 meters in the reservoir area were flooded, and some village houses in the reservoir side entered the water, which made production and life burdensome. It leads more than 4,000 people from different villages to move to the villages in the south of the reservoir from 1974 to 1976. From 1982, the MRW started to focus on providing the drinking water for Beijing citizens. The total area of the reservoir is 336,000 mu, almost occupying 240,000 mu of cultivated land, and the water storage capacity of MRW breakthrough regularly.

Today in the 21st century, with the socio-economic development, it is concluded by the analysis of the water environmental condition of MRW that some water quality indexes of MRW exceed the standard and then deteriorate. There is a severe contradiction between the environmental protection of the reservoir and the sustainable socio-economic development of the reservoir area. To alleviate the contradictions and promote the sustainable development of the reservoir water environment and the reservoir area, some targeted measures are put forward and live environmental monitoring in MRW.

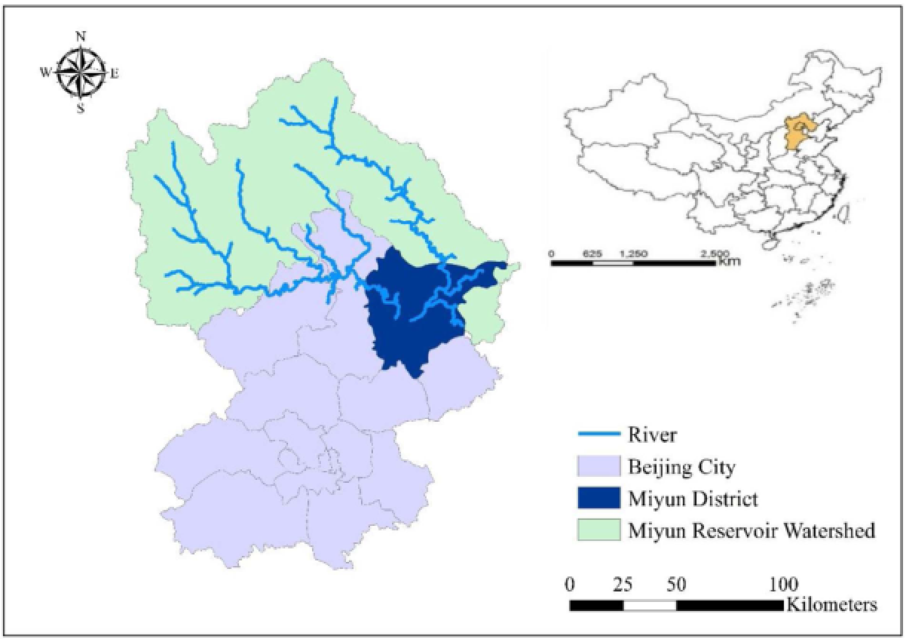

Figure 1. Location of Miyun District, north China., (Cui et al. 2018)

2.3 MAIN FOREST WATERSHED COMPOSITIONS

This thesis focuses more on the upstream of MRW. It is important to prevent soil erosion and ecological environment damage, and the only appropriate way is to close the mountains and restore forests. It is not suitable for the reclamation of mountains and land and large-scale destruction of landform mining activities. The composition of MRW has a direct and significant impact on its soil condition. To explore the regional soil changes, it is essential to observe the effects of land-uses, watershed scale, soil properties, forest vegetation, topography, and water distribution in the MRW. It is an excellent way to find the best management approach by understanding the compositions of MRW.

2.3.1 LAND-USE AND WATERSHED SCALE

Under the influences of climate change and human disturbance, considering land saving and pollution control, land-use planning and watershed-scale design are important measures for sustainable development of the MRW. The function of the ecosystem is closely related to human life, and land-use change is one of the main driving forces for the degradation of ecosystem service functions. The MRW has a tight human-land relationship and dramatic changes in ecosystem service functions, and the objective of an analysis of the basin is from 1990 to 2009. The MRW covered an area of 90-183.6b square kilometers and reached a maximum depth of 153.98 meters in 1994, but the current depth is 131 meters. Some researches applied the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST model) to analyze the water quality purification and smelting model to study the impact of watershed land-use changes on ecosystem service functions (Li et al., 2013). During the end of the 20^{th} century to the beginning of the 21^{st} century, land-use in MRW changed dramatically. From 1984, the MRW even had no natural landscape and agricultural land. Still, the woody vegetation and herbaceous vegetation accounted for a large proportion in the watershed area, which is reached 272.7% and 57.6% (Table 1). The area of farmland, grassland and water body decreased by almost half than before, and the area of forest land, building land and bare land increased by 30%, 230% and 282%. With the changes in land-use, ecosystem service function correspondingly changed significantly. The following situations are the soil conservation function, and the carbon fixation service increased by 46% and 19%, respectively. However, water supply service and water purification function decreased by 3% and 25%, respectively, and some eutrophication leads to the decline of water quality and harms the structure and function of the ecosystem. According to the Landsat TM image and combined with the GPS of the field survey, the upstream of MRW shows an intuitive interpretation of the land-use map (Figure 2.).

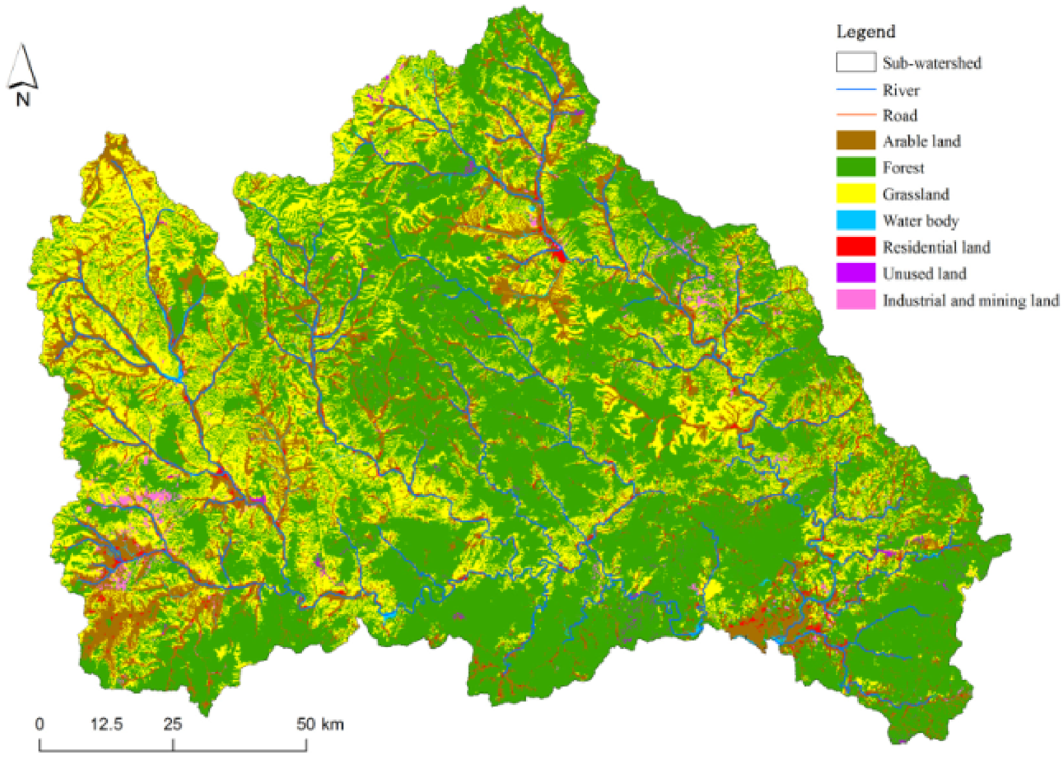

Figure 2. Land-use map in the upper catchment of Miyun Reservoir (Xu et al. 2016)

Land-use information contains a large number of human activities, which can be controlled by changing ecosystem types, patterns and ecological processes directly affect the ecosystem service function. Quantitative assessment of the relationship between land-use change and ecosystem service function change has become a hot topic in sustainable development (Li et al., 2013). In MRW, a method combing the total amount of land-use and water pollution was proposed, a new land-use index was established, and the water quality was tested. Land-use not only has an impact on water and nutrient in the soil but also impact the runoff. Overall, from 1990 to 2009, there is 36%, 19% and 5% of farmland in MRW were converted into the forest, grassland and building land. Part of the forests has also been transformed into farmland (7%) and grasslands (6%). The transformation of grassland to other land types is the most drastic, which leads up to 65% of the grassland has been converted to the forest and 15% to farmland. At the same time, about 70% of water bodies were converted to other land types during this period, which indicated that the surface water resources in the MRW experienced a relatively distinct decline process (Li et al, 2013). These frequent mutual changes among forest-grassland-agriculture, forest management and a series of human activities have key factors of land-use change in MRW.

Table 1. G1 land-use in the catchment area of the Miyun reservoir in 1984 (International Lake Environment Committee.,http://www.wldb.ilec.or.jp), and 2019 (Pei et al., 2019).

Land Types	Area (km2) (1984)	Area (km2) (2019)	Proportion(%) (1984)	Proportion(%) (2019)
Grassland	9010	4258	57.6	27.17
Farmland	1173	3234	7.5	20.62
Wetland	265	124	1.7	0.79
Forest/shrub	4333	7750	27.7	49.45
Construction land	844	279	5.4	1.78

2.3.2 SOIL PROPERTIES

The soil in MRW is divided into four categories, which are cinnamon soil, brown soil, mountain meadow soil, and calcareous soil. It is a good way to determine the soil properties by observing what kinds of chemical elements in soil, such as organic carbon, total nitrogen, and heavy metal. In general, the natural secondary forests and grassland soil always have a higher quantity of organic carbon and nitrogen than plantation and farmland soil. At the same time, some environmental variables influence these elements to change in the soil as well. Soil comprises a significant pool and plays an important role in the global C and N cycles (Batjes, 1996). As urban planning and modern industrial development are concentrated in the upper reaches of the MRW, soil erosion risk and pollutants have become current significant problems. The upstream reservoir is exposed to a moderate erosion situation, and there are 715,848 hectares of land subjected to water and soil erosion in 2003. Accounting for half area is slightly and moderately at risk, which is occupied 45.60 and 47.58% of soil erosion (Tian et al, 2009). The average annual water soil erosion modulus is 12-16 tons/ha, and the annual runoff is about 5.72 million tons. This area has severe water soil erosion and is considered as the critical area of soil and water conservation project in China in the 21st century (Tian et al, 2009).

2.3.3 VEGETATION

The forest vegetation in the MRW is mainly original secondary forest and artificial forest, which includes *Pinus tabulaeformis, Platycladus orientails, Robinia pseudacacia and Larix gmelinii*, and the natural secondary forest species are mainly broad-leaved and mixed wood forest. The study found that the forestry species in MRW had an earlier development and had low species diversity, and most of the forests were monoculture conifers. Various forestry vegetation also influences the changes in water and soil over time. Some coniferous and broad-leaved forest has more moisture evaporation capacity, which leads per unit area of forest land and soil can lose more moisture. High biodiversity and relatively high-quality vegetation coverage not only has a small sediment output load, but also has a good sediment interception, and the total carbon sequestration has been greatly improved as well. In addition to bare land in MRW, the rest of the land's vegetation coverage is increased from 2000. The vegetation coverage increased from 44.39% in the 1970s to 65.10% in 2008, among which the coverage of broadleaf and mixed wood forest increased significantly, but grassland and agricultural land decreased. In 2007, the Livelihoods and Landscapes Strategy (LLS) launched a project which aims to restore biodiversity and productivity through forest landscape restoration.

2.3.4 TOPOGRAPHY

The MRW is the largest reservoir in the region of Beijing-Tianjin-Tangshan, north China, which locates in a remote mountainous area. It belongs to the warm temperate semi-humid semi-arid continental monsoon climate. The terrain of the entire watershed is high in the northwest and low in the southeast, and the water flows from the northwestern mountain by hills, and the mountain area accounts for about 2/3 of the total area. Most of the northwest is covered by 1,000-2,293 meters in elevation, while the southeast is covered by low mountains and hills (Pei et al, 2019). The content of soil organic carbon and other chemical elements are influenced by elevation, slope, and average annual precipitation. By integrating slop, land cover type and vegetation coverage, soil erosion can be divided into different grades for research. The reservoir is shallow in the north and deep in the south, and its maximum depth is 63.5m (Gu et al.2006). The upstream of MRW covers an area of 1.5254 million acres. The morphological types are moderate and lower mountains, hill and valley, and the altitude varies between 150 and 1,800 m above sea-level (Tian et al, 2009).

2.3.5 WATER AREA

There are four medium-sized and above-ground reservoirs in the Miyun area. The MRW is an important source of water, and it is the largest water conservancy project in northern China, with a maximum storage capacity of 4.375 billion cubic meters and a maximum water surface of 188 square kilometers. The water quality of the reservoir is directly affected by the upstream region, so the maintenance and improvement of the ecosystem service function in the upstream region are of considerable significance to the ecological security of the local area and Beijing. Moreover, with the increasing storage of water resources, this situation becomes more and more prominent. The period from June to September is the flood season, accounting for more than 80% of the annual precipitation. The spatial distribution of precipitation is more in the southeast and less in the northwest. The primary inflow rivers are the Bai River, Chao River, and the seasonal rivers, which are Qingshui River, Baima River, Dujiangyan River and, etc (Figure 1).

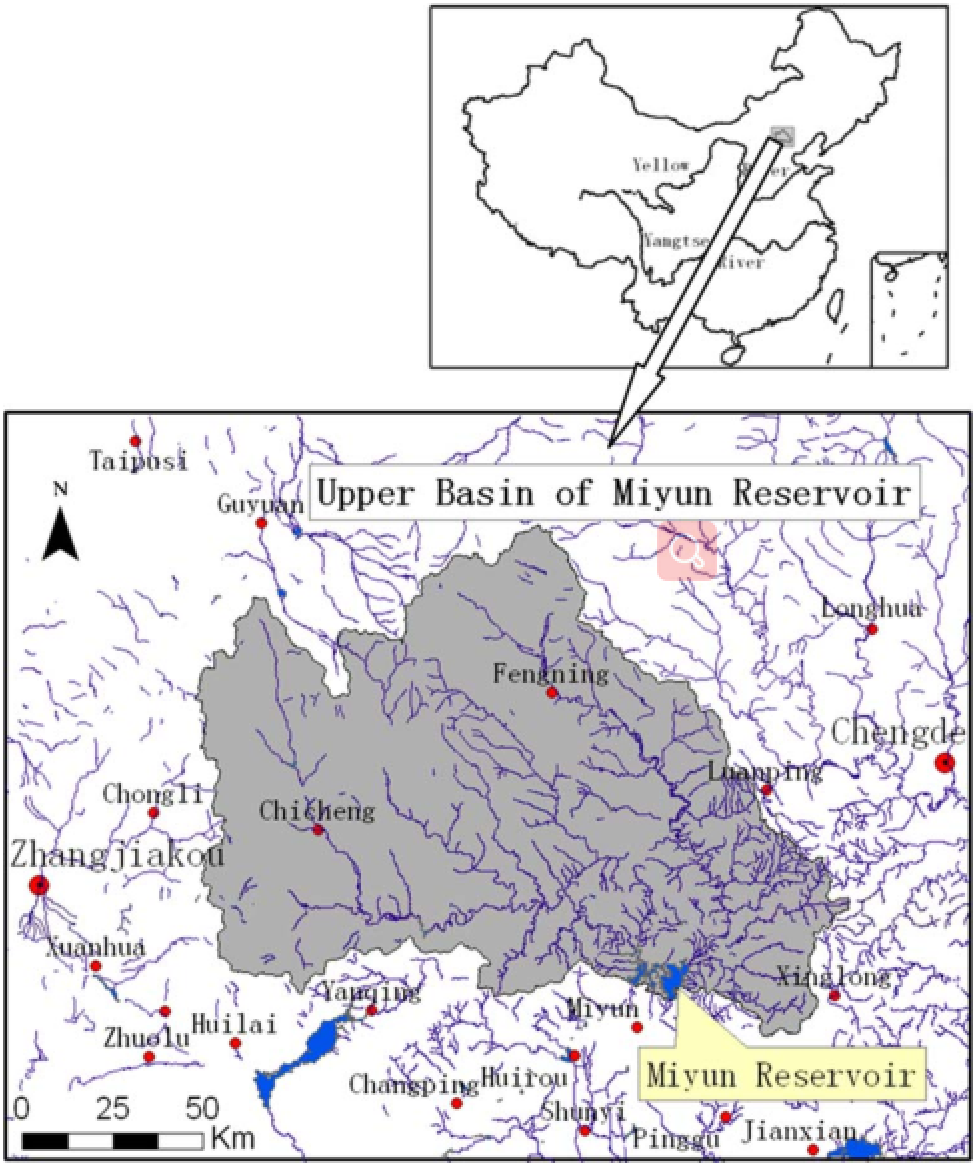

Figure 3. The upper basin of the Miyun Reservoir. (Tian et al, 2009)

2.4 SOIL CONDITION AND INFLUENCE FACTORS

Soil is one of the essential components of the environment, and the changes in soil continue to have indirect and direct impacts on our lives. The soil in MRW is divided into cinnamon soil, brown soil, meadow soil, and chestnut soil four categories. Severe soil erosion is getting more and more attention from the government, which leads to more and more soil research in the MRW. It is the most appropriate method for analyzing soil conditions by considering the environmental factors around the soil and its internal factors.

2.4.1 EXTERNAL CAUSES

2.4.1.1 CLIMATE CHANGES

Climate is considered to be the main factor that affects vegetation type, plant growth and litter decomposition, thus affecting the balance and soil organic matter cycle of soil (Wang et al, 2012). In the MRW, the north is a semi-arid forest-steppe climate area, and the south is semi-humid mountain climate area (Li et al, 2013). The upstream of MRW is located in the warm temperate zone, in which evaporation is higher than precipitation each year. According to the Cohen climate classification, there are also warm and dry for winters and hot and humid in summers. The average annual temperature is about 8-10°C in the upstream, the precipitation always concentrated from June to August (Table 2), and the frozen period always happened from December to March. The soil condition usually connected with the evapotranspiration and precipitation, which are mostly influenced by climate change. According to different data collection and analysis from the MRW, the precipitation intensity, duration and frequency affect the soil loss and runoff. Precipitation characteristics are controlled by climate changes and are external factors of soil loss and erosion.

Table 2. D_Climate Data in the Miyun reservoir, form 1980-1983 (International Lake Environment Committee.,http://www.wldb.ilec.or.jp)

Climatic data at Miyun Station, 1980-1983													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Ann.**
Precipitation [mm]	1	5	7	27	28	95	124	162	43	19	6	3	520

2.4.1.2 VEGETATION COMPOSITION CHANGES

Different vegetation cover and soil management measures can directly affect the soil properties, which is also caused by changes in land-use. Human's transformation of land-use often causes many changes in soil organic matters. It is well known that when soil organic matters change from forest or grassland to farmland, and it usually loses carbon and nitrogen (Li et al, 2013). With the population growth, economic development and the implementation of a series of local policies, the land-use of MRW has undergone drastic changes. The upstream forest vegetation is mainly natural secondary forest and artificial forest. The natural secondary forest is mainly mixed broad-leaved forest types. The species mainly include *Pinus tabulaeformis, Platycladus orientalis, Robinia pseudoacacia, and Larix gmelinii* (Wang et al, 2014). The more complex the forest structure, the higher canopy storage, and the season will change with the precipitation distribution pattern.

Currently, the vegetation coverage rate increased to 65.10% (2008), among which the coverage of broad-leaved forest and mixed forest increased significantly, and grassland and agricultural land decreased. Though some improvements have applied in the natural landscape in the MRW, ecosystems have become increasingly fragmented and isolated from the beginning. The study found that the forests in MRW developed early and had low species diversity, and most of them were single monoculture conifer forest types. Different forest species composition leads to different ecological compensation standards. For the reason that the MRW is in closed watersheds, sediment production is the result of interactions between multiple factors. Among these many environmental impact causes, vegetation is the most important environmental control factor in water soil erosion. In the mountain areas and low urbanization of MRW, the land-use types are dominated by vegetation, especially forests. It will significantly reduce the sediment in the water, runoff, and soil capacity, and this conclusion strongly supports the government's policy of returning farmland to forests.

2.4.1.3 WATER QUALITY

The water quality of the MRW affected by the upstream region, so the maintenance and improvement of ecosystem service functions in that area are of great significance to ecological security. At the same time, the water body in the reservoir flows into the soil surface, which influences the soil properties by runoff. Soil water is the material basis for plant growth and survival. It not only affects the yield of forest trees, field crops, vegetables and fruit trees but also affects the distribution of plants on the land surface.

The forests provide important water services through hydrological processes --- redistribution of precipitation by the canopy, litter, and soil layers (Ma et al, 20117). The water entering the forest can be divided into three categories, which are forestry water storage, forest evaporation, and runoff. It is important to keep the runoff water quality in a good standard because runoff includes surface runoff and underground runoff, which is water for people to use. The researchers calculated water regulation by increasing vegetation water retention, soil water and ground litter water. Because there are many industries and other constructions were built around the upstream, large amounts of nitrogen, chemical pollutants from fertilizer and entered into the reservoir. These pollution sources increase the risk of eutrophication and toxicity in MRW. In order to observe and protecting the water quality, it is necessary to reduce water soil erosion in the upper reaches of MRW and improve the ecosystem, such as returning farmland to forest and repair degraded land with apparent effects.

2.4.1 INTERNAL CAUSES

2.4.2.1 SOIL MOISTURE

Soil respiration is an integral part of the terrestrial carbon cycle, and the water mostly impacts the soil respiration. According to the analysis based on different data in the upstream of MRW, the soil moisture there is too high, and water fills most of the soil pores, preventing ventilation. The mineralization rate of organic carbon is low, which is conducive to the accumulation of organic carbon. Thus, it is necessary to keep the soil moisture, thereby maintaining the respiratory system of the soil.

The change in soil moisture is due to soil heat capacity, surface albedo, plant growth, evaporation and transpiration. These effects cause sensible heat flux, latent heat flux, radiant flux and momentum exchange, which causes climate change and changes soil moisture. The precipitation is the primary source of soil moisture, and precipitation events may strongly stimulate soil respiration during dry seasons than wet reasons. There is a strong interaction between soil moisture and climate change.

2.4.2.2 SOIL EROSION

Soil erosion is one of the serious environmental issues around the world, which has brought great harm to the national economy and development. Sediments and nutrients from the forestland entering the reservoir due to soil erosion are the primary sources of pollution and affect the water supply security of Beijing and the operation and life of the reservoir by damaging water conservancy facilities. According to the survey by Beijing Remote Sensing, Miyun county has more than 1000 km^2 area of water soil erosion. Soil erosion is divided into six grades according to its soil erosion modulus ($t \cdot km^{-2} \cdot a^{-1}$). There is a different situation of soil erosion intensity in the MRW areas, the overall situation is slightly erosion, and moderate erosion area is increased over time. It mainly occurs in the land-use for low hill areas. Due to the thin soil layer and hilly landform in the MRW, the soil erosion range tends to increase under the influence of human economic activities, which also indicates that the potential risk is relatively severe in this area. A combination of advanced technology with RS and ARCMAP GIS can determine soil erosion degree, and also can make up for the uncertainty factors by replacing the surface. The erosion risk assessment indicators are land cover, vegetation cover and slope. These large-scale data provided by remote sensing can revisit the same land area regularly, therefore making a significant contribution to regional risk assessment of soil erosion through the rapid development of relevant indicators.

Some researches showed that the upstream of MRW is exposed to moderate risk of soil erosion. 715,848 hectares of land suffered from soil erosion in 2003, accounting for 46.62% of the total area, and most of the soil erosion areas are at low and moderate risk, accounting for 47.58% and 45.60% of the soil erosion areas, respectively (Tian et al, 2009). Soil erosion mainly depends on topography, vegetation cover, soil taxonomic units, precipitation and land cover (Fan et al. 2004). The intensity, duration and frequency of rainfall affect soil loss, and the rainfall characteristics are controlled by climate and are external factors of soil loss. The soil surface erodibility is determined by the composition and binding strength of soil taxon, and soil cover can indirectly reflect the erodibility of soil (Tian et al, 2009). The accurate determination of soil erosion is of great significance to the formulation of erosion control measures.

2.4.2.3 SOIL pH

Soil pH affects soil organic carbon and total nitrogen by regulating the microbial activity, and higher pH value may have adverse effects due to accelerated decomposition of soil organic matter. By analyzing particle size through a 2 mm sieve of soil to get the soil pH. The slope and water bodies are significantly correlated with soil pH. In the MRW, there is a significant negative correlation between soil volume and soil pH. Different soil pH can influence the growing vegetation and wildlife, even cause soil erosion. Soil pH value is not only a fundamental property of soil but also an important chemical index affecting the physical and chemical properties of soil. It directly affects the existence, availability, migration, and transformation of various elements in the soil. Previous studies have shown that robust acidic soil environment can weaken the activity of soil microorganisms and reduce their ability to decompose and transport SOM and nutrient elements. Thereby reducing the turnover of soil organic carbon and facilitating the accumulation of organic carbon.

2.4.2.4 CHEMICAL ELEMENTS

2.4.2.4.1 C, N, AND P

Soil forms a major reservoir and plays an important role in the global carbon and nitrogen cycles (Batjes, 1996). Carbon and nitrogen loss from soil emissions of greenhouse gases into the atmosphere may be one of the causes of global warming, either natural or human-made. Therefore, the sequestration of soil organic carbon (SOC) and control of total nitrogen (TN), as a more direct emission reduction measure, which is increasingly concerned by the scientific and political circles worldwide (Wang et al, 2012). Total nitrogen and total phosphorus (TP) in soil and water are the leading indicators reflecting the nutrient level of water bodies, and there is a distinct correlation.

Some related studies have shown that the water body of MRW is affected by human activities. The content of nitrogen compounds in the water body is high, the total nitrogen in the whole reservoir is 0.96 mg/L on average, and the content of phosphorus in the water is low. Climate, topography and soil properties are considered as main environmental controls of SOC and TN (Wang et al, 2012). For the climate, it is considered to be a major factor affecting vegetation types, plant growth and litter decomposition, and thereby affecting soil organic matter (SOM) (Wang et al, 2012). Human activities of land-use often cause many changes in SOM. It is well known that when soil changes from forest or grassland to farmland, the soil usually loses its C and N. By using ArcGIS software to correlate analysis which was performed to determine the relationship between TOC, TN and environmental variables such as climate, terrain, and soil properties, as well as the relationship between these variables (Wang et al, 2012). The climate factors that play a role in the input and decomposition of SOC are mainly temperature and precipitation. SOC, TN, and TP balance in soil depend primarily on surface vegetation and land-use.

2.4.2.4.2 HEAVY METAL ELEMENTS

Heavy metals in the soil are derived from natural factors and human activities, such as soil erosion, transportation, industrial pollution, mining and settlement of the atmospheric particulate matter. The upstream of MRW has lots of small mines industries, which are the main source of soil pollution and erosion. As the only surface water resource in Beijing, MRW directly affects the water quality, health and safety of Beijing residents. Due to the rich gold mine resources in the upstream of the reservoir, the tailings produced by the ore mining and refining process have already had a certain impact on the soil and water system in the area. The pollution of Cd, Pb and Hg in the soil is severe, and the average content exceeds the background value of Beijing by 12.1, 4.4 and 28.1 times, respectively (Li et al, 2013). Among them, mercury pollution is the most serious, up to 6.74, more than 100 times the background value of Beijing (Li et al, 2013). The heavy metal in the coarse-grained soil is mainly derived from the parent rocks, while the metal in the fine-grained soil is mostly artificial. Statistical analysis shows that there are three sources of metals are Cd, Cu, Hg, Pb, and Zn had anthropogenic sources; Co, Cr, Ni and V had mixed anthropogenic, and natural sources; and As and Be had natural sources (Li et al, 2014). The studies show it is determined that the high concentration of Cr and Ni in the surface soil mainly comes from the iron mining near the northeast part of Chao River, and the land-use for agricultural or farmland is responsible for the increased concentration of Cu and Zn in the soil (Luo et al, 2010). On the east bank of MRW, Cr and Cu are the most potentially harmful heavy metal chemical elements. Strengthening the monitoring and evaluation of the relevant mining areas in upstream of the MRW, and effectively repairing and remediating, avoiding the pollution of the water and soil erosion is necessary.

3.0 METHODS

3.1 STUDY SITES AND EXPERIMENTAL DESIGN

I collected different data from the World Lake Database website and academic researches, which were published between 1980 to 2019. All of these study areas are located in the upper basin of MRW, which is located in Miyun county, northern Beijing, China. The MRW is across the principle rivers of Chao River and Bai Rive, with a total storage capacity of 4.375 billion m^3. The upstream of MRW is located between latitude 40°19'N-41°31'N and longitude 115°25'E-117°33'E, covering an area of 15,788 km^2 (Wang et al, 2011), about 80% of the total upstream area (Chao River and Bai River). The morphological types are moderated and lower mountains, hill and valley, and the altitude varies between 150 and 1,800 m above sea-level (Tian et al, 2009). Its terrain is high in the northwest and low in the southeast. The northwest is dominated by Zhong Mountain with an elevation of 1,000-2,290 m, while the southeast is mostly low mountains, hills and some plains. The vertical distribution of climate within the upstream of MRW is apparent. Maying and Dushikou are divided into two climate zones, that is, the middle humid zone semi-arid forest, grassland climate zone in the north and the warm, humid zone semi-humid mountain climate zone in the south. The average annual precipitation is 488.9 mm, and the precipitation distribution decreases from southeast to northwest. The soil layer in the MRW is thin, and the soil there is divided into four categories according to Chinese Soil Taxonomy (Chinese Soil Taxonomy Research Group 1995), which are cinnamon soil, brown soil, mountain meadow soil, and calcareous soil. The average annual soil erosion modulus is 12-16 tons/ha, and the annual runoff is about 5.72 million tons (Tian et al, 2009). This area has severe soil erosion and is considered as the critical area of soil and water conservation project in China in the 21st century. The main land-use types are grassland, farmland, artificial deciduous coniferous forest, mixed aspen and birch forest, natural secondary oak forest, and shrub forest. Some unreasonable development and utilization of mining, road construction has led to severe soil erosion around the upstream watershed area. It is of great significance to judge the degree of soil erosion risk in this area, protect and improve the ecological environment around the reservoir, ensure the sustainable development and rationally plan of land-use around the MRW.

Soil sampling is collected from different experiments and researches, which are preliminary reports released in the 21st century. I compared the existing data and samples, and classify the sample data according to land-use types and different depths of soil. At the same time, analyze data changes in the past around forty years to find the best management practice of MRW.

There are many factors affecting soil properties. Different environmental factors have different sensitives under the same disturbance factor, and the same environmental factors have different sensitives under various disturbance factors. Therefore, in order to ensure the reliability of the results, it is necessary to control a single variable to conduct a comprehensive analysis of changes in soil properties. I classified the internal and external factors affecting soil properties and analyzing the current situation, at the same time combined with the management methods after meta-analysis. Many soil erosion prediction models are developed based on RUSLE (Revised Soil Loss Equation) and remote sensing map. The RUSLE represents how climate, soil, topography, and land-use affect rill and interracial soil erosion caused by raindrop impact and surface runoff (Renard et al., 1997). At the same time, remote sensing maps can observe the changed in the distribution in study areas. After collecting the last 30 years' data to analyze the soil condition in the upper basin MRW by using Microsoft Office Excel 2003 and then observing the trends in soil condition changes to find the best management for the MRW.

3.2 DATA COLLECTION AND PROCESSING

(1) Precipitation and topography

The precipitation is the primary source of surface runoff and soil moisture and is the basis of hydraulic erosion. Rainfall closely related to soil erosion includes rainfall intensity and rainfall erosivity. A previous study (Zhang et al, 2002) in the MRW found that the estimation of average rainfall erosivity using the daily rainfall is relatively consistent with the actual value. There is an index R to represent the potential capacity of rainfall, which causes soil erosion, and this is a kinetic index of soil detachment and transportation caused by rainfall (Li et al., 2013). Some studies about runoff in different slop plots have shown that runoff and erosion amounts are mainly affected by rainfall and rainfall intensity in the maximum period and their product. However, their correlation with average rainfall intensity is relatively weak. In the upstream of MRW, the rainy season is mostly concentrated in June to August (Table 2., Figure 4), and the potential evapotranspiration and temperature are changed with the precipitation. There is a difference in soil erosion intensity between different topography, so total rainfall is a prerequisite for research. In the same rainfall area, the rainy seasons' distribution can help to understand the overall situation of regional soil erosion. The precipitation characteristics closely related to erosion are basic precipitation standards, erosive storms, and so on. These values are related to factors such as vegetation and topography. Thus, there are many different values, even in the same location.

By comparing the R factor (Figure 6) and topography in the upstream of the reservoir, and collect and analyze various types of data in the same period to obtain changes in soil erosion under the influence of topography and precipitation. The topography information of the MRW is obtained from different experimental remote sensing images, and the ArcGIS map and the climate and precipitation changes in the corresponding regions are found from the *China Meteorological Science Data Sharing Service Network.* Soil loss and erosion classes for the different periods during each year are significant for analyzing by combining the collected data.

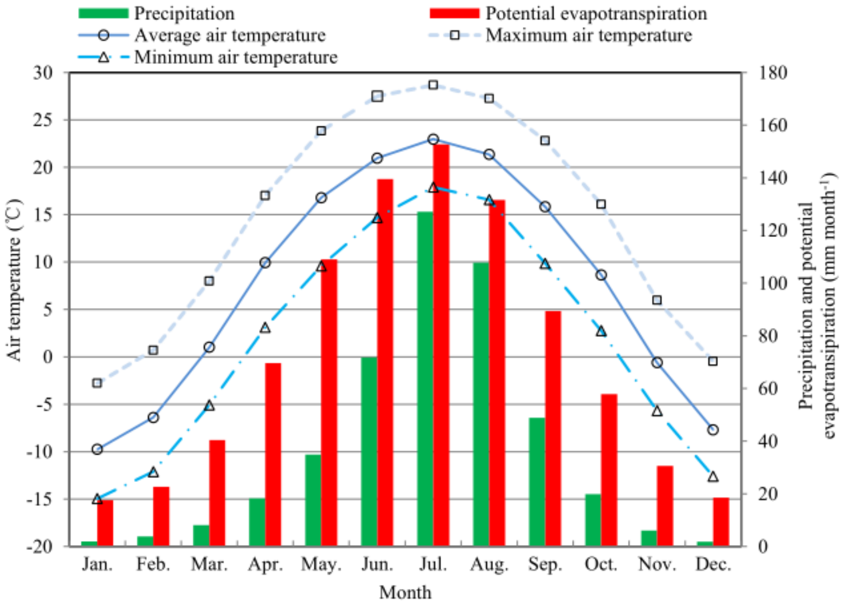

Figure 4. Monthly average precipitation, potential evapotranspiration, and air temperature during 1961-2008 in the Miyun Reservoir catchment. (Zheng et al, 2016).

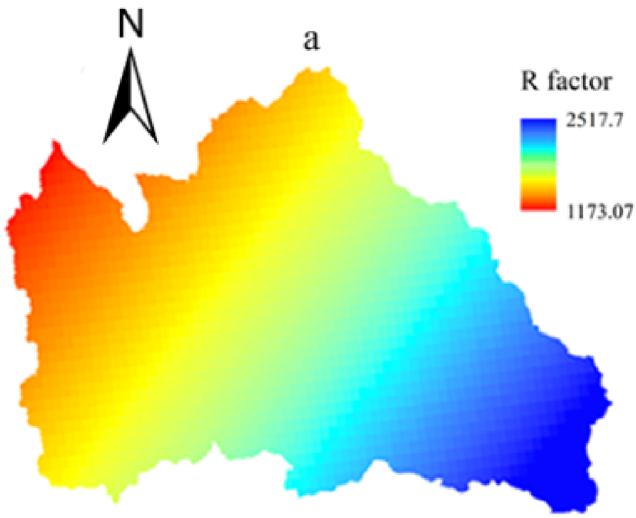

Figure 5. The distribution of R factor. (Li et al., 2013).

(2) Land-use types

The primary land-use type in the upstream of MRW, which influence soil properties, are the forest, grassland, farmland, water and some mining areas (Table 1). Most studies believe that increasing vegetation cover is an important measure to control soil erosion. Different vegetation types and their combinations have various benefits in controlling soil erosion. A reasonable land-use can maintain the moisture, nutrients and plant seeds in the soil, which is conducive to the growth of vegetation and further enhance soil erosion control. According to the previous research, grassland, farmland, water area, forest land, and mining plots are identified by GPS (Figure 6) and according to different types of land-use soil sampling for analyzing. The forest lands accounted for almost half of the total upstream reservoir (Table 1), the primary forest land type is deciduous brad-leaved forest, and all sorts of forest lands area are increasing over time.

In contrast, other land-use types are slowly decreasing over time (Figure 7). By using ArcGIS software analysis, vegetation cover and land cover information used to evaluate the risk of soil erosion in the upper basin of MRW (Tian et al., 2009). The soil was divided into three classes of depth, which are 0~10 cm, 10~20 cm, and 20~40 cm.

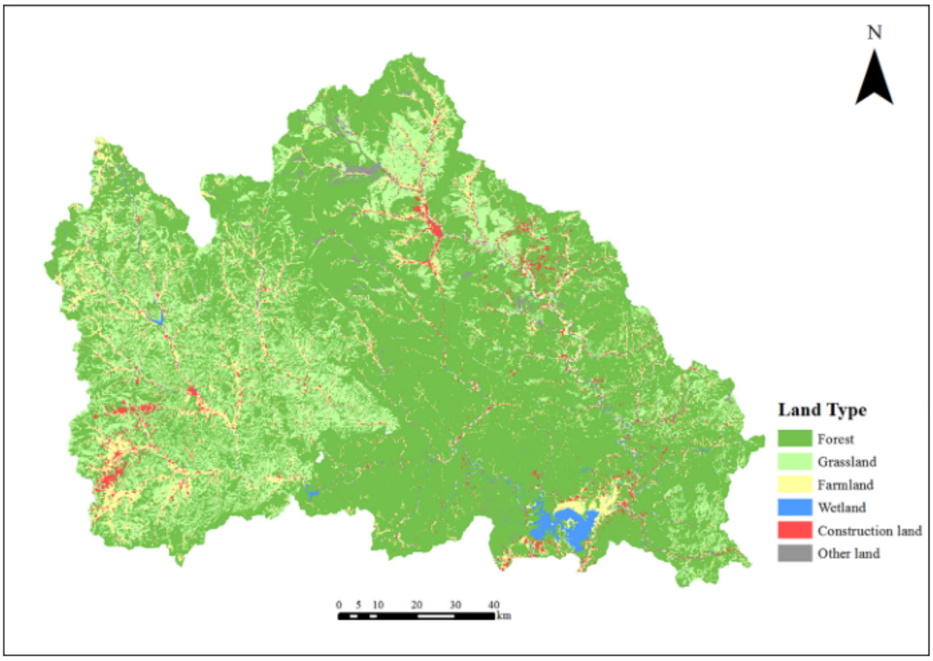

Figure 6. Land-use types of map of the upstream in MRW (Pei et al., 2019).

At the same time, sample collection is carried out along the upstream area around gold mines, and heavy metals in the soil were determined by element XR (Li et al., 2013). Vegetation coverage and soil erosion intensity are divided into six grades, and the data collected in the corresponding grades of erosion degree and C/N content areas are obtained. After the superposition analysis, the spatial distribution of soil erosion grade and the carbon sequestration capacity of different regions are obtained to analyze the soil status.

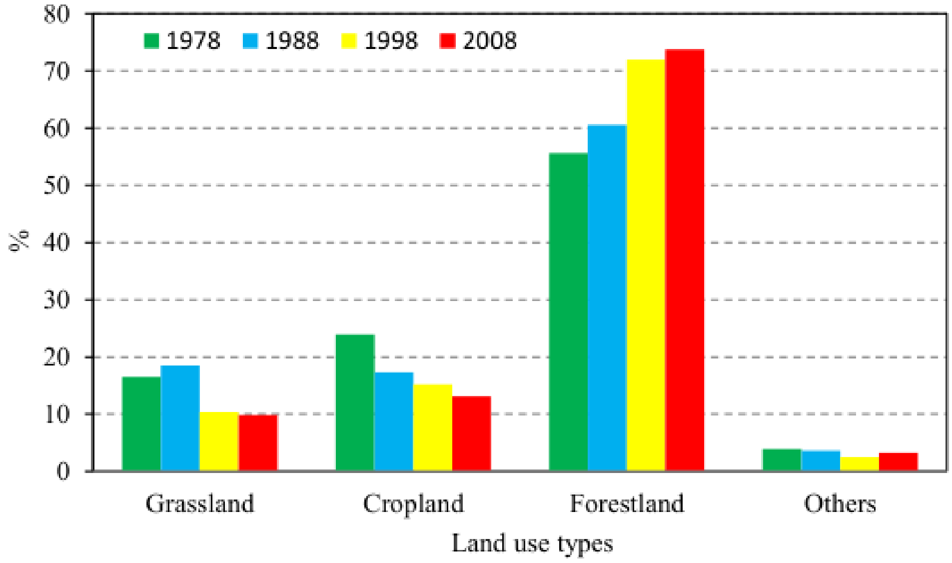

Figure 7. Land-use composition of MRW in 1978,1988,1998, and 2008 (Zheng et al., 2016).

It is necessary to analyze water quality. Basin water and precipitation both are primary sources of soil water. Forestlands have a significant impact on the capacity of water in the reservoir. Water flows through the soil affects surface runoff, evaporation, and various chemical indicators such as eutrophication in the water, which also affects the soil quality. Water samples were collected by previous studies, based on digital elevation data provided by the global topography database with a spatial resolution of 30 m, researchers used the hydrological analysis tool in ArcGIS 10.1 to delineate sub-watersheds (Xu et al., 2016). By comparing each of the six water quality variables in the upper reaches of MRW, it is easy to get the analysis and reflection of the water body's quality. The water quality purification and smelting model from the RUSLE method can be used to estimate the SOC and TN in upstream soil. When I ignored other pollution sources first and only considered non-point source pollution, it was easy to get the higher the TN output is, the less water purification function will be.

Careful consideration of the above influencing factors, drawing bar charts to show the extent of soil properties by different grades, and find the best management plan finally.

4. RESULTS AND ANALYSIS

4.1 LAND-USE TYPE'S CHANGES

The present land-use types of the upstream MRW are water areas, grasslands, forests, croplands, and construction areas, and the forests include Larch forests, Chinese pine forests, Aspen-birch mixed forests, Liaodong oak forests, and shrublands. The majority of the soil pollution comes from the upstream construction lands of mine factories. According to the data collection, the forest lands are planned to increase since 2000, but there was some decrease in the water areas, grasslands, and farmlands (Figure 8). In order to achieve an optimal allocation of different land-use types, almost more constructions are built near the MRW based on convenient transportation and sound economic foundation (Figure 8). The government sacrificed water areas, grasslands and farmlands to ensure the total runoff and pollutant control in upstream of MRW. It shows that the adjustment for the government plan to achieve an optimal situation of soil condition in the MRW upper basin. Between 2000 and 2020, it is easy to find that there are no apparent changes for land-use types in 2005, but the adjustment planning almost reaches the expectation in 2020 after 2005. Under the proper management plan, the land-use types area has been showing a steady trend of change, and this steady trend cannot leave without the regular monitoring of land-use type's changes.

The forest soil organic carbon pool is an important part of the terrestrial soil organic carbon pool. The SOC of the forestry land is always concentrated in the soil surface layer, and it is mainly distributed in the soil layer at a depth of one meter. The increase of different forestry land-use types in the upstream of MRW forms a natural organic carbon storage space with nutrients, and it keeps the balance between the number of transformed plant residues entering the soil and the amount of SOC respiration and decomposition under the action of microorganisms. As a result, the natural accumulation also promotes the formations of different forestry types, especially the deciduous forest.

This kind of change cycle is undoubtedly a virtuous cycle for increasing forest cover.

The farmlands decreased a lot because of returning farmland to forest policy in China, which can reduce agriculture encloses tideland for cultivation with the city overdevelopment. At the same time, the long-term fertilization of farmland will cause soil acidification and increase soil erosion. Since 1980, continued reduction in farmlands area and large-scale expansion of forest land areas were shown up (Figure 7 and Figure 8). The former can directly reduce the pollution of some human-made and chemical pollution. At the same time, the latter can also lessen the TN output of the basin to some extent due to the better nitrogen absorption and removal ability of the forests and the carbon sequestration rate increased significantly although the substantial expansion of construction lands during this period reduced carbon sequestration to some extent, compared with the increase of forest lands and the decrease of farmlands. In general, farmlands, forests and grasslands are in high-speed conversion among each other. Although the rise of forestland area can improve the water quality purification function, this kind of feature is mainly affected by the construction area. The total area of the construction lands are not large, but the damage to the water quality purification function was extremely significant. The carbon sequestration showed a strong correlation with the forest lands, and with the increase of forestry area, carbon sequestration increased significantly. The left farmlands and grasslands need to be managed strictly. Reasonable fertilization not only changed the amount of SOC but also affects the composition of soil organic carbon. However, the effect of fertilizer management on SOC is complicated. The organic carbon in the soil will decline without fertilization or a single application of nitrogen fertilizer for a long time, but after that, the SOC will gradually lose the ecological balance. Promote ecological agriculture, reduce the application amount of chemical fertilizers and pesticides year by year has become the main task at present in the MRW area.

The water areas had not changed much. Because the MRW is the main source of drinking water for Beijing citizens, it is important to improve water quality. The government already re-registered and re-examined the enterprises in the upper basin of MRW. All of the enterprises should use the wastewater treatment facilities and should not discharge any wastewater to the environment directly.

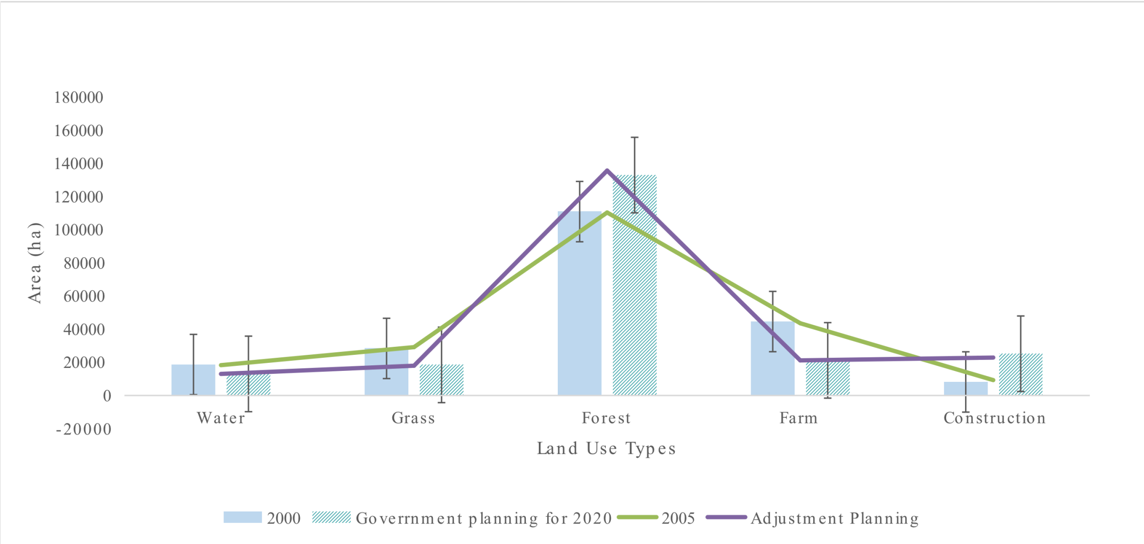

Figure 8. The area of land-use types in MRW in 2000, 2005, adjustment planning from 2006 to 2015 and the expectation of government planning for 2020.

4.2 AVERAGE SOIL EROSION CLASSES

The results also show that the upper basin of the MRW's common area in the last 30 years is 1472.91 km^2, and the soil erosion class is deficient among six classes (Table 3). Most of the eroded soil is on the lower class to the moderate class, which accounts for 95.41% of the total area. The MRW surrounding areas have the different situation of soil erosion intensity, and the overall situation of soil erosion is low. The soil erosion mainly occurs in the use of arable land in the low hills. Due to the thin soil layer and hilly landform, this area's soil erosion tends to increase under the influence of human economic activities, which also indicates that the potential degree of soil erosion in this area is relatively high. In the long run, if there is no proper adjustment of land-use in MRW, it may lead to the increase of soil erosion area, aggravate soil and water loss in hilly areas. More seriously, it may also affect the water quality of reservoirs, coordinated development of water supply quality and ecological environment in Beijing.

Table 3. Miyun watershed average of soil erosion in different classes.

Miyun Watershed	Total area (km^2)	Very low		Low		Moderate		Serve		Very severe		Extremely severe	
		km^2	%	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%
	1472.91	1030.71	69.97	271.03	18.40	103.80	7.04	35.19	2.40	26.98	1.84	5.21	0.36

4.3 AVERAGE SOC, TN CONTENTS AND ITS INFLUENCING FACTORS

Different depths of soil in the upstream MRW have different levels of pollution. At the same time, different land-use types also have a different average of the TOC, TN, and heavy mental chemical elements. Table 4 shows the average SOC and TN content in 3 classes of soil depth, and it is easy to find that the shallower the soil layer, the higher the SOC and TN content. For the SOC and TN's content in the soil, grassland has the average value, and the other types of lands decrease with the depths of the soil layer. Aspen-birch mixed forest, Liaodong oak forest, and shrublands have a more significant change. There is no SOC and TN in 20~40 cm depth of soil layer for shrublands. The main climate factors that play a role in the input and decomposition of SOC are temperature and precipitation. The SOC tends to decrease slowly with the increasing of the temperature and precipitation, and the deeper the soil layer, the lower the temperature and soil water content. Figure 9 and figure 10 show that the trends of SOC and TN in three classes of the soil layer, and as the depth of the soil deepens, both of organic carbon and nitrogen content show a downward trend. For the 0~40 cm of the total average SOC and TN content, the soil has different contents, which depend on the land-use types. The SOC usually has a higher content in 10~20 cm depth, and the TN has a higher content in 0~10 cm depth. However, the grassland soil layer of 10~20 cm has the highest SOC content among the three classes of depth (Table 4).

In general, these 7 land-use types' SOC and TN contents show the following conditions: Aspen-birch mixed forest > grassland > Liaodong oak forest > shrub land > Larch forest > Chinese pine forest > farmland and Aspen-birch mixed forest > grassland > Liaodong oak forest > shrub land > Larch forest > farmland > Chinese pine forest (Table 4). Throughout the 0~40 cm depth of soil, the Aspen-birch mixed forest always has the highest SOC and TN, which has about 24.27% and 23.35% content among all seven land-use types. Chinese pine forest and farmland always have the lowest SOC and TN, and there are significant differences in both of the SOC and TN contents in different soil layers, which always have great decreases of carbon and nitrogen with the increases of soil layer's depth.

Table 4. Average SOC and TN content (g/kg) with different depths in different land-use types.

	0~10 cm depth		10~20 cm depth		20~40 cm depth	
land use types	Average TOC content (g/kg)	Average TN content (g/kg)	Average TOC content (g/kg)	Average TN content (g/kg)	Average TOC content (g/kg)	Average TN content (g/kg)
grassland	30.38	3.16	31.28	2.81	29.29	2.60
farmland	11.29	1.13	9.41	0.98	7.31	0.77
Larch forest	15.45	1.50	12.71	1.25	10.27	1.03
Chinese pine forest	14.87	1.11	9.80	0.75	7.30	0.93
Aspen-birch mixed forest	45.71	3.94	33.48	2.84	23.96	2.20
Liaodong oak forest	34.09	2.58	26.61	2.04	20.39	1.64
shrub land	26.91	2.51	24.50	2.31	-	-

The temperature and precipitation are the factors most closely related to the temporal dynamics of soil's CO_2 emission. Figures 9 and 10 indicate that the SOC content in all soil layer depths shows a trend of a slight decrease with the increase of temperature and precipitation. Correlation analysis shows that the negative correlation between SOC content and temperature and precipitation is exceptionally significant. By comparing figures 10 and 11, the partial correlation analysis shows that the influence of precipitation on SOC content in each soil layer is greater than that of temperature, which is around -0.069 in temperature and -0.170 in precipitation. The sensitivity of SOC decomposition to temperature changes in the short term mainly determines the sensitivity of active itself, and the long-term process will mainly depend on the sensitivity of inert it. If the temperature increases, the soil moisture will reduce, and oxygen diffusion will increase, so that the substrate effectiveness may increase. However, the effects of substrate availability on SOC and TN decomposition are not entirely consistent. As the TN increases in the soil, the content of SOC increases as well. However, the different depths of the soil layer may reflect different SOC content. 10~20 cm depth of soil layer has a more significant relationship to SOC content than the other two depths, and 0~10 cm depth of TN content in soil is less affected by SOC content between the other two depths (Figure 10). Figure 9 also shows that SOC content in all soil layers from top to bottom is positively correlated with the altitude. These factors all have a specific correlation with SOC content and different degrees of influence on it. At the same time, soil water content (soil moisture) is an essential medium for microbial growth, and it also directly affects soil gas exchange, microbial nutrient supply, and temperature. The effect of temperature changes on SOC and TN decomposition is closely related to changes in humidity, and changes in soil moisture directly affect the amount of CO_2 in soil respiration. 10~20 cm depth of soil layer has a more significant of SOC content among the other two depths (Figure 9). According to some early researches, soil microbial biomass carbon content is closely related to soil pH, and these effects change the response of SOC decomposition to temperature changes. The increase of pH value promotes TN mineralization, especially the nitrification rate increases with the increase of pH, which are attributed to the increase of pH value, and it can also increase the solubility of organic matters.

Table 5 indicates that the partial correlation analysis of SOC content with all six main factors of different land-use types shows that the most significant factors affecting SOC content in grassland and farmland are TN content and annual mean temperature. TN content and soil water content had the most significant influence on SOC content in Chinese pine forests and aspen-birch mixed forests. TN content and pH had a great significant effect in Liaodong oak forests, and Larch forests' SOC content and pH also affect shrublands' SOC content.

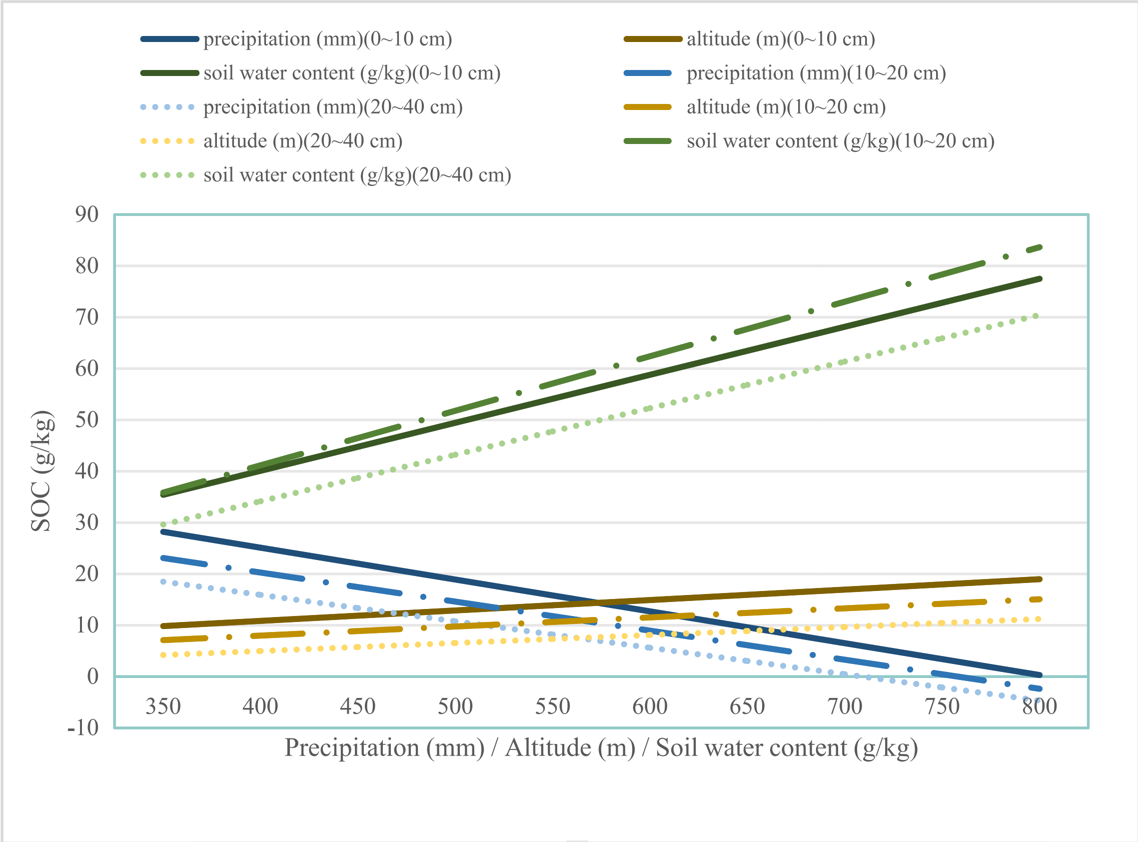

Figure 9. Average SOC content (g/kg) varies with the precipitation (mm), altitude (m), and soil water content (g/kg) in 0~10 cm, 10~20 cm, and 20~40 cm depths. Precipitation and altitude have the highest effects in 0~10 cm soil depth, and soil water content has the highest level effects in 10~20 cm depth of soil layer.

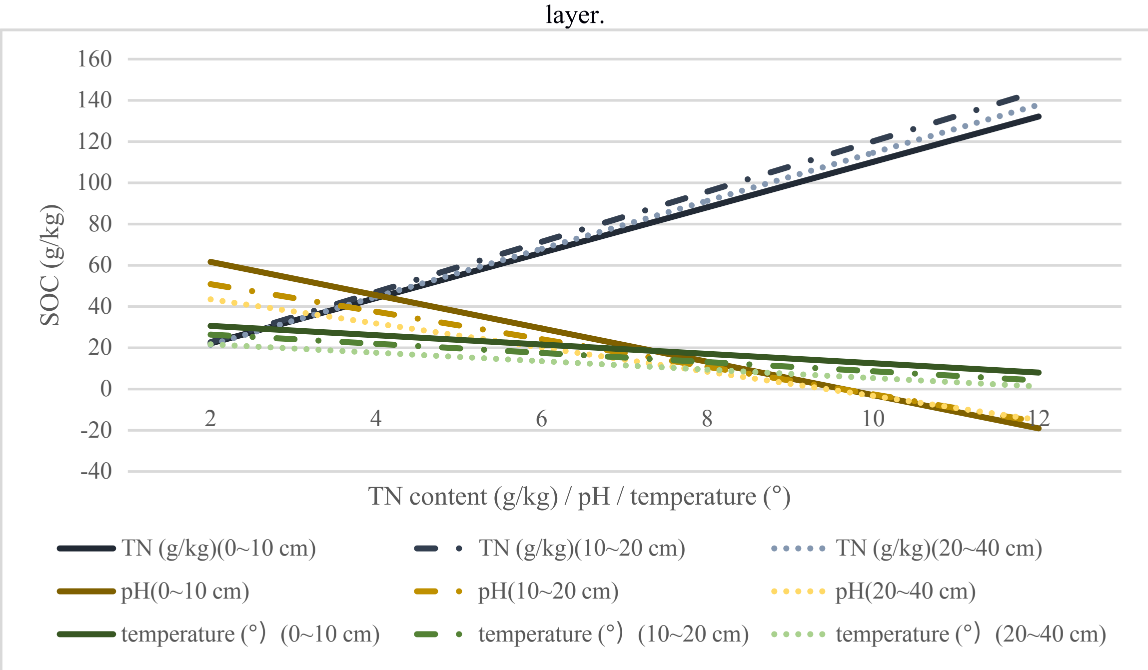

Figure 10. Average SOC content (g/kg) varies with the TN (g/kg), pH, and temperature (℃) in 0~10 cm, 10~20 cm, and 20~40 cm depths. Temperature and pH have the highest level in influencing SOC content in 0~10 cm depth of soil layer, and TN content has the highest level in influencing SOC content in 10~20 cm depth of soil layer.

4.4 HEAVY MENTAL ELEMENT POLLUTANTS

There are seven different major heavy mental chemicals, which are Cr, Cu, Zn, As, Cd, Hg, and Pb, and soil pollution mostly concentrated on four different land-use types, which are grassland, forestland, recreation land, and wasteland. The metal concentrations vary widely and may reflect natural variability and anthropogenic sources of metals (Figure 11). Figure 11 indicates that Cr, Cu, and Zn have a higher content in pollution, which Cr has almost 237 mg/kg in recreational land. As and Pb have an intermediate level of pollution content, and Cd and Hg have a lower content among seven kinds of pollution elements. According to the records and standards of Beijing's soil pollution elements, Cr, Cu, and Cd are all above the average, and the other four elements' values are lower than the average. The gathering of upstream mining areas mainly causes these pollution factors, and the soil heavy metal elements content, which closer to the sampling point of the gold mining areas, is higher than the average. Forestland and recreational land have more soil types that are polluted. Overall, these 7 types of heavy metal elements have the following impact comparison: Cr > Zn > Cu > Pb > As > Cd > Hg (Figure 11). Acidic wastewater from upstream gold mine tailings causes soil pH to decrease and heavy metal elements to accumulate. By comparing with the SOC, pollution elements have a more variable range. Recreational land includes the farmlands has the highest contents of elements, which may be related to the use of organic fertilizers to the surface soil of the crops in the mining areas. Some differences in the spatial distribution of all elements, which indicates that the research area has been affected by human activities to some extent. The overall soil pollution level reached a seriously dangerous level, mainly due to the discharge of mining wastewater and the leaching effect of tailings sand. The tailings of gold ore are usually left by beneficiation through amalgamation or cyanide method. It causes not only the pollutants of Cr, Cu, Zn, and other heavy metal elements contained in the gold ore itself but also highly toxic substances such as mercury and cyanide. Under the scour of rainfall, it will infiltrate into the ground, which will easily cause the soil metal content to exceed the standard. According to survey statistics, most of the gold mine tailings are randomly stacked on the roadside, and there are no protective measures, which will directly cause pollution to the surrounding soil environment and have great potential ecological risks.

Figure 11 indicates that recreational land has the most serious heavy metal chemicals pollution, and the soil in forestland and grassland is at a relatively low level of heavy metal chemical pollution. Hg and Cd were hardly be found in the study area. After the heavy metal elements enter the soil, only the soluble and exchangeable states with migration have biological availability, which can adsorb with crops, transport and redistribute in plants. These heavy metals exist in the soil in the form of soil solutions and solid phases. The former is transported by mass flow, while the latter is directly obtained to affect plant and water quality.

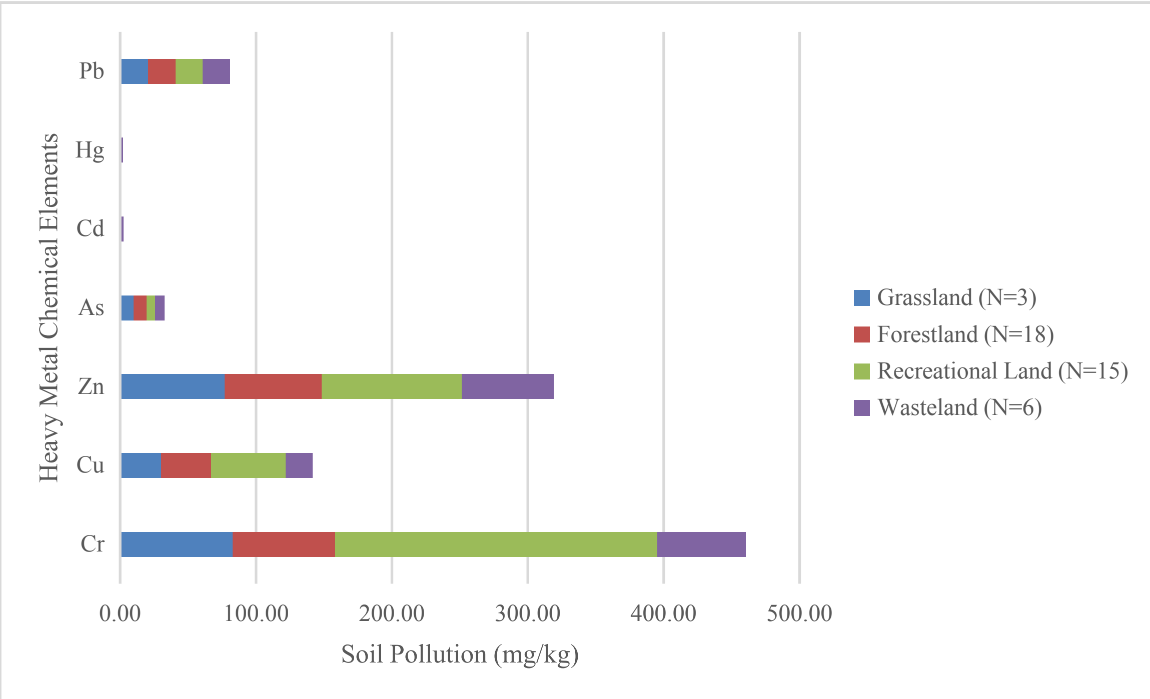

Figure 11. Pollution (mg/kg) of different heavy mental chemical elements in major land-use types. N represents the number of areas, the total number is 42, and the values of N indicate the numbers of experimental areas. All heavy metal chemical elements get from 0~40 cm depth of the soil layer.

5. DISCUSSION

5.1 CURRENT CONDITION OF SOIL

The soil in upstream of MRW is affected by the land-use types, and climate changes more obviously. The land-use types, especially forestry lands, influenced the SOC and TN directly (Table 4). The TN, temperature, precipitation, pH and soil moisture are all belonged to the factors which change the MRW soil condition.

The SOC and TN content in the soil is the dynamic balance between the input of organic matter such as biological residues into the soil and the loss of organic matter mainly caused by the decomposition of soil microorganisms. At the same time, these contents are also varied with the climate, topography, vegetation, and land-use types' changes, which are affected by human activities. In the natural ecosystems, climate and soil conditions are the main determinants of soil organic carbon balance. However, in natural-artificial composite ecosystems where human activities are prevalent, soil organic carbon balance is primarily determined by surface vegetation and land-use types. Land-use types and land management is as the critical activities affect the natural ecological system of human. It can not only change the condition of land cover, affects the distribution of plant roots and litter to the input of the soil, but also by improving soil conditions affect SOC decomposition rate, which leads to the change of SOC. Therefore, different types of land-use and vegetation have a different distribution of plant roots, litters entering the soil, different ways of anthropogenic soil disturbance, and SOC content and its distribution in the soil profile also has different variations.

The SOC and TN are both distribute vertically in the upper basin of MRW in all seven land-use types. The distribution of plant roots on the soil surface is large and extensive. However, with the increase of soil depth, the transport of water and nutrients downward is limited, and the distribution of roots also presents a decreasing trend. Climate (temperature and precipitation) plays an essential role in the process of SOC input and decomposition. On the one hand, climate conditions affect vegetation types and vegetation productivity, thus determining the amount of organic carbon and nitrogen input into the soil. On the other hand, from the perspective of the SOC output process, microorganisms are the main driving force for its decomposition and turnover. The response mechanism of SOC and Tn decomposition to temperature changes involves many processes and properties in different soil layers. Climate affects the decomposition and transformation of organic carbon by microorganisms through changes in soil moisture and temperature. The results indicate that the SOC and TN content in farmland soil usually lower than the grassland and forest land soil (Table 5). Thus, the increased intensity of SOC and TN content reduction and management practices generally support the results, and the government plans to decrease the farmlands a lot for future development. It is because that the intensive farming can increase fertilizer amendment and crop residues, so improving land management practices such as preferential crop residue management is necessary. The soil layer depth of 10~20 cm has more SOC content, which reflects that a higher root density in this layer and there are large amounts of organic carbon can be stored in deeper grassland soil (Figure 10).

The SOC and TN are usually significantly correlated with climate. According to consulting relevant information, SOC and TN content increase with the soil water content, and decrease with the decreasing of temperature. Human activities can influence the climate of temperature and precipitation, which have effects on soil runoff and moisture. In recent years, the government implemented the policy of returning farmland to forests and grasslands to achieve a better ecosystem in the MRW. Because reservoirs have shrunk and water quality has deteriorated, it is important to reduce the amount of water used for agriculture and irrigation, so that ensure urban water source use downstream of Beijing. Overall, a better way to manage soil property and SOC and TN dynamical balance in upstream of MRW is changing the land-use types at a regional scale.

Under the influence of global warming, the maximum loss of SOC will occur in northern forest areas, where Beijing located. The low-temperature conditions in the north region were originally not conducive to the decomposition of plant litter and SOC. However, with the increase of temperature in the high northern latitudes, it will accelerate the decomposition of organic matter in the surface soil and emit more CO_2 into the atmosphere, causing severe losses of SOC in the region. At the same time, heavy summer precipitation will affect the water content and soil moisture, change the input of forest litter and soil respiration rate, and then increase the amount of forest SOC storage. It may lead to faster release of CO_2 from forest SOC pools, which may also affect forest SOC accumulation and its dynamic balance. These changes in forestry species types will affect soil microclimate and structure, which even may cause a forest fire. In order to find a better management method, it is necessary to keep the land-use types always in eco-balance.

5.2 EFFECTS OF HEAVY METAL ELEMENTS

Heavy metal elements are the main reason for soil erosion and pollution. Combining the comparison of heavy metals in the soil of the gold mining area with the background value of Beijing, the results can be obtained that Cr, Cu, Cd, Pb, and Hg are originated from human activities and As and Zn mainly comes from natural. Figure 11 shows that recreational land is more polluted among four land-use types, which can reflect a large number of human activities occurring on recreational land with higher elevations closer to the dominant areas of human activity. Cr is the primary pollutant and has the highest content in the recreational land. The distribution of trace metals in upstream MRW soil of different land-use types is stable and regular, and from the data, we can see the pollution degree and migration rate of metals in the soil.

Four land-use types of grassland, forestland, recreational land and wasteland are located in riparian soil. Cr, Cu, Cd, Zn, and Pb are mostly from coal combustion, which is a primary anthropogenic source and a significant input channel atmospheric deposition.

Collect data and analysis of soil trace metals in MRW can not only find the valuable information of potential impact of soil timely but also promote coal-burning area limits to further reduce deposited pollutants in maximum yield study.

5.3 PROPER WAY FOR WATERSHED MANAGEMENT

In order to reduce the pollution source and decrease soil erosion, it is necessary to imply a proper sustainable management method for better development in the MRW. It is suggested to ban fish farming in the reservoir area and nationalize the lands. The government will accelerate the implementation of ecological vegetation restoration and soil erosion control projects in the river basin. At the same time, promote the full range of biological control measures and reduce the impact of pesticides and fertilizers on the water quality of the reservoir. For the issue of human activities, we should adopt the policy of population relocation and set up a particular area of the river basin for people so that to improve their living standards and create employment opportunities and solve the problem of labour surplus in the area around the reservoir. To strengthen the water environment is also needs to be noticed because the water source is significant to the ecosystem and relates to the soil condition. Global warming and precipitation changes both have specific effects on forest species' NPP (net primary productivity). In order to reduce the uncertainty of the prediction of the impact of future climate change on soil conditions, combined effects of changes in multiple climate factors should be considered comprehensively.

The upstream of MRW has concentrated with much gold mining and density population. The government will establish and implement a system of valid pollution discharge permits, and strictly control the total amount of pollutants discharged locally in areas where upstream populations are concentrated and where pollutants are concentrated. Raise funds for the development of reservoir areas through multiple channels and properly arrange the production and living activities of immigrants. At the same time, the research on the response of soil activated carbon pool and inert carbon pool to temperature rise should be strengthened. The difference in SOC's sensitivity to dynamic change and some micronutrients should be analyzed each day. The process has a deeper understanding of the size and direction of SOC and TN changes.

Accurately quantifying the relationship between land use and soil properties will help manage land use effectively and support decision-making. The results show that different land-use types have a significant influence on the distribution pattern of agricultural pollution, especially on TN and SOC, and some pollutants under different vegetation have distinct time dynamic characteristics. Thus, we need to observe ecosystems in the MRW regularly and determined that land-use types, precipitation and human activities at the field scale. Some on-site management measures should be taken around the study area. A more systematic study of the relationship between soil organic matter stability, substrate availability and quality, microbial properties, and the relationship among moisture, pH, and other factors and soil and nitrogen decomposition in response to temperature changes should be made for different climates, soils, and land-use types.

6. CONCLUSION

There are soil erosion conditions of different intensities in the surrounding areas of the upstream MRW, and the overall soil erosion degree is spent gently. A small part of the moderately eroded area mainly occurs on the land-use types of croplands in the hilly area of the bottom of the mountains. Different land-use types have a dynamical change for soil properties. Due to the thin soil layer in the MRW, the influence of human economic activities has led to a slow increase in the soil erosion area. It also illustrates the potential dangers of soil erosion in this area. It is necessary to notice that to combine with remote sensing, GIS, and other technologies, data analysis of soil conditions in the region is taken regularly, and surface runoff and pollutant emissions are well controlled. In order to protect the ecological environment around MRW and reduce soil erosion, it is significant that to adjust the land use in this area, apply related policies to control the development of metal minerals in the upstream, limit the farming activities and strengthen the construction of forestland in water conservation areas. These are important measures and fundamental guarantees to solve the problems of the capital’s environment and development so that we can achieve sustainable economic development. Therefore, the combination of a set of long-term integrated forest management strategies of soil protection and apply a long-term supply for ecosystem balance is important. In the upstream of MRW, the primary objective is to guide the integration of short-term adaptive management strategies with forest management techniques close to nature and fundamentally change the decision to serve the ecosystem of megacities best. To sum up, when using soil organic matter models to simulate changes in forest SOC storage, in addition to temperature, precipitation and CO_2 concentration, various factors such as deforestation, forest fires, and land management and utilization must be considered. In order to reduce the uncertainty of the simulations, the results can not be ignored.

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