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Non-Point Source Pollution Management in Yangtze River Basin, China

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Abstract

Pollutants are regarded as a harmful substance when it is discharged into the environment; it enters the water environment and affects the environment's physical, chemical, and biological properties. Non-point source comes from various sources that its pollutant will enter the water body, stream bank in directly. Best management practice is an important measure for watershed non-point source pollution control and its goal is to minimize pollution reduction in basin. This chapter helps people to understand about non-point source pollution, best management practice, and control for non-point source pollution via the best management practices. Furthermore, this chapter are proposed the best management practices to reduce nutrients and control non-point source pollution as using bio-pretention method via pond and vegetated buffer or vegetated swale in agricultural runoff; riparian buffer restoration or storm drain channel to reduce runoff velocity before conducting to be filter in storming condition of agricultural runoff; using vegetated filter under roof or strip form with urban runoff; sediment restoration or vegetated roof to reduce quickly sediments, then using wetland stores to keep nutrients from non-point source pollution in building runoff; using soil amendment and restoration as well as dry well to keep big amount of grease in oil/grease runoff; using vegetated strips or roof, wetland channel, especially grassy buffer in road runoff; and natural wetland, wetland banks, and vegetated buffers in forest runoff.

Keywords: Non-Point Source Pollution, Water Pollution, Best Management Practice, Pollution Control.

Introduction

Surface water accounts for almost of the earth, it includes river water, lake water, pond water, streams, ditches, coastal water, sea water. In recent years, some surface water resources at downstream river basin have been severely depleted due to pollutants from using process in human life as agriculture, urbanization, and etc.

This rapid urbanization process leads to change land use and the area of rivers as well as lakes is gradually shrinking. Moreover, urbanization also leads to the development of industrial zones, modernization, and increasing water demand. From that, increasing of waste, which is released into the environment.

Water pollution is the phenomenon of water sources, which are contaminated by harmful substances and it is dissolved or settled in the stream bank leading negative changes to water quality and affecting to human life, human health, and ecosystem. Basing on pollutants, water pollution is classified into pollutants of bacteria, virus from organic waste, heavy metals from industry, and chemical compounds from agriculture as fertilizers and pesticides, in which waste water from agriculture causes mainly non-point source pollution (NPS). Non-point source pollution has a significant impact on regional water environments worldwide (Wu et al., 2024). In particular, nonpoint source pollution from agriculture is becoming the major cause of water pollution and lake eutrophication, which has seriously affected the quality of the water environment and the health of the ecosystem, and constrained the sustainable development of the economy and society (Yang et al., 2013). Therefore, the management of non-point source pollution has become one of the most pressing challenges worldwide (Ding et al., 2023; Ren et al., 2022).

Best management practice is a useful method in watershed non-point source pollution management because it can minimize pollution reduction before runoff is released to water bodies. Yangtze River Basin is a big watershed with an area of about 1.8 million km², lies between 24.50°N-35.75°N and 92.43°E-122.45°E (Sang et al. 2012). Most parts of the basin have a subtropical monsoon climate (Zeng et al. 2011, Zhang et al. 2008, Zhang et al. 2005) and the annual mean temperature in the basin is between 15°C and 19°C (Zhang et al. 2008) with its average annual precipitation of 1067 mm (Xu et al. 2008). The quickly economic development of China in recent years causes a lot of disadvantage about environment issue in this basin. One in those causes is pollution from non-point source. It is regarded as a complex non-point source pollution characteristic of the Yangtze River Basin. In this chapter, to control and improve the NPS pollution, the best management practices (BMPs) for non-point source pollution control needs to be established because it is suitable with complex characteristic of non-point source pollution, decreases NPS pollution and allows reducing nutrient load as well as prevents pollutant into the basin environment. In addition to that, it can be applied popularly in community with flexible characteristic, simple implement process, less costly and high effectiveness. Therefore, the establishment of best management practices in the Yangtze River Basin is a necessity, emergency working, and has important significance for ecological environmental benefits.



Fig. 1: Distribution of sub-basins in the Yangtze River Basin

Water Environment and non-point Source Pollution

Water plays an important role in the ecological balance in the Earth and water quality degradation threatens socioeconomic development as well as human health. Water is one of the renewable resources for sustaining all forms in our life, food production, economic development, and for wellbeing. It is impossible to substitute for most of its uses, difficult to de polluted if it is not impacted by human activities. Water is also one of the most manageable natural resources as it is capable of diversion, transport, storage, and recycling. All these properties impart to water its great utility for human beings. The surface water and groundwater resources play a major role in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation, recreational activities. Unfortunately, population growth, unplanned urbanization, and industrialization have resulted in increased pollutant loadings into water bodies that cause distortions to its ecosystem and are also detrimental to human health (Kumarasamy M, 2015). Pollutants are regarded as a harmful substance when it is discharged into the environment; it enters the water environment and affects the environment's physical, chemical, and biological properties. That phenomenon is called water pollution. In other words, the water pollution is the release of polluting substances into surface water (lakes, streams, rivers, estuaries, and oceans) and groundwater to the points that the substances interfere with beneficial use of the water, makes unsuitable water for desired use aim or water quality impairment. Water bodies can be polluted by a variety of substances (Chen M et al. 2010) including pathogenic microorganisms, organic waste, nutrients, toxic chemicals, sediments, heat, oil, and radioactive substances. Moreover, water pollution comes from either point sources or non-point

sources, such as discharged sources from the industrial facility or the city sewerage system or the pipe of determined sources. A non-point source is a very broad, non-confirm from various sources that its pollutant will enter the water body, stream bank in directly such as the runoff from an agricultural region. Water pollution from point sources is easier to control (Shrestha et al. 2008; Carpenter et al. 1998) than non-point sources due to the contaminated water has been collected and conveyed in one single point, while the pollutants from non-point sources is more control difficult (Shrestha et al. 2008).

The real problem with water pollution today is non-point source pollution. It is recognized as the single greatest threat by the population growth and social development. The concept of non-point source pollution was first put forward and studied in North America and it was a subject of intensive research, especially in the 1970's and 1980's (Novotny and Olem,1994). Non-point source pollution is caused by rainfall moving pollutants over, through the ground, and washing it into rivers, lakes, wetlands, coastal waters and ground waters. In other words, non-point source (NPS) pollution refers to the contamination of water bodies, such as rivers and lakes, by dissolved or suspended pollutants transported primarily through surface runoff and groundwater flow (Wang et al., 2020). The sources of NPS pollution are diverse unlike that from industrial and sewage treatment plants, which come from the same sources. Runoff from rainfall and melting snow carry along with them contaminants from different sources known as NPS pollutants. These pollutants range from natural to man-made pollutants which are usually deposited into water bodies by runoff water. Moreover, in the process of non-point source pollution, pollutants in the soil are infiltrated and converged into rivers and lakes through runoff generated by rainfall, soil erosion processes and soil leaching, which in turn trigger a series of environmental problems such as eutrophication of water bodies (Zhang et al., 2024). In addition, isotope analysis technology applied to the field of water pollution source identification research found that migration of nitrogen in soil has an obvious lag phenomenon, specifically 19.2 % to 35 % of nitrogen fertilizer in soil for more than one year (Fuchs et al., 2023).

Point source pollution is normally from factories power plants, sewage treatment plants, underground coal mines and oil well (Harding et al. 1998; Wang et al. 2001). These sources are collected and identifiable. However, unlike point source pollution, non-point source pollution comes from many diffuse sources. In addition, the land surface can be generated by most of land use activities including agriculture, forestry, urban and suburban development, mining, as well as others. Particularly, (1) from excess using of fertilizers, herbicides, and insecticides of the agricultural lands and residential areas; (2) Oil, grease, and toxic chemicals from the urban runoff and the energy production; (3) Sediment from improperly managed construction region, agricultural and forest lands, and eroding stream banks; (4) Salt from irrigation

practices and acid drainage from the abandoned mines; (5) Bacteria and nutrients from the livestock, pet wastes, and the faulty septic systems; (6) Atmospheric deposition and hydro modification are also sources. Especially, agricultural activities such as tillage practices and land application of fertilizer and animal manure are significant factors contributing to NPS pollution. NPS pollutants are a major source of water quality impairment in many parts of the globe (Novotny, 1999; USEPA, 2003). The transport and transformation of NPS pollutants relate strong from the human activities and natural factors (Karr and Dudley, 1981; Gordon and Majumd, 2002; Yoder and Rankin, 1995). Agricultural runoff accounts for a large proportion in non-point source pollution because agricultural operations discharge a broad range of contaminants including manure, fertilizers, pesticides, and eroded soil particles (Claphamm et al. 1999; Johnson, 2001; David et al. 1997; Novotny, 1982). Their loads are affected by surface runoff, interflow, and ground water base runoff from the farms and agricultural land. The most bothersome contaminants are ammonia, nutrients, pathogens, sediments, bacteria, pesticides, salinity, selenium, and thermal modification. Ammonia is a toxic for fish and nutrients can impair quality of water. Manure is a significant source of nitrogen, phosphorus, biochemical oxygen demand; it causes disease for organisms like waterborne diseases. When in the waterbody has so much manure and chemical fertilizer are spread onto fields for agriculture enhancement, the excess of nitrogen leaches into ground water and enters adjacent streams. Pesticides can contaminate into water bodies via several routes including spillage, improper storage, and those pesticides carry away from the farm into nearby waters and causes non-point source pollution. The USEPA (2003) estimates that non-point source pollution is from the agriculture activities accounting for 60 percent of all the impaired or threatened surface waters and overgrazed pastures, fertilizers, pesticides, sediment, nutrients from agricultural lands, animal wastes from feedlots. The excess of non-point source pollution influences the overall quality of life and more than 50% of the excess sediment loadings in many water bodies is contributed by the erosion of agricultural areas (Ritter and Shirmohammadi, 2001), affecting more than 10% of the impaired rivers and streams in the United States (USEPA 2006). The other important NPS pollutants of concern are the nutrients such as nitrogen (N) and phosphorus (P), affecting approximately 9% of the impaired rivers and streams (USEPA, 2006). Sediment loading in the streams causes increased silting, therefore decreasing the stream flow, and also acts as a carrier for transportation of nutrients.

NPS pollution affects the quality of the environment on which humans depend and can directly or indirectly affect public health (Holas et al, 2002; Hunter, 2003), such as affects the beauty and health of surface water (Ding et al. 2010), or leading massive fish kills due to severely decreased levels of oxygen in the water. From that, a condition is known hypoxia phenomenon occurs when excessive algae

block out sunlight and killing off underwater plants leading to depleting oxygen in the water surface. Although, these organisms are harmless in water quantities and exist naturally. Nevertheless, they will grow very quickly if the eutrophication occurs. Then, the fish and shellfish eat this algal; they will be ingested toxins, which the algae produce. When the people eat this seafood, they can be sick, and shellfish ingests these algae become poisonously to humans. In addition to that nonpoint source pollution not only affects ecosystems, it can also be harmful to the economy (Leeworthy et al. 2000).

Parameters and Key Effect Factors to Non-point Source Pollution

Nonpoint source (NPS) pollution from agricultural areas has become one of the biggest challenges in maintaining surface water and groundwater quality. NPS inputs, especial in agricultural activities are regarded as the result of nitrogen and phosphorous. The amount of NPS pollution and its grave consequences on the environment and human health increase yearly around the globe due to the development of agricultural technologies, putting more land under cultivation, the rising use of chemical fertilizers and pesticides, and urbanization (Hossein Ahmadi, 2023) leading toxic algal blooms, oxygen depletion and loss of biodiversity. The increasing of toxic content and hazardous substances lead to reduce dissolved oxygen concentration, and appear eutrophication (Ding et al. 2010; Potter et al. 2004; Farenga and Daniel, 2007), acidification trend. Novotny and Chesters (1982) note: Non-point source is highly dynamic and randomly occurs at intervals closely related to the hydrological cycle. It is also highly variable and ranging across several orders of magnitude. The most water qualities of non-point source impacts during or after storm events, in winter and early spring. Moreover, non-point source pollution is unidentifiable and difficult to control with traditional water quality monitoring techniques. The primary water quality parameters related to non-point source pollution includes sediments, nutrients, heavy metals, synthetic organics, pH and dissolved oxygen. Especially, nutrient components from agricultural activities have resulted in large amounts of nitrogen (N) and phosphorous (P) (Ding et al. 2010). They are the most important parameters in water quality impairment (Lu et al. 2013; Ullrich and Volk, 2009; Zhao et al. 2011; Shen et al. 2011). When these nutrients accumulate with high enough concentrations in a waterbody, they can seriously affect to organisms living and human health. Nitrogen and phosphorus are essential factors for plant growth, but if using is too much, it can lead a condition called Eutrophication. Eutrophication results in an overproduction of organic matter (Li et al. 2012), particularly the microscopic plants called algae (Bricker et al. 1999). That is green masses of algae, which grows on a pond or lake. This excess of algae blocks the sunlight by native bottom-dwelling plants. When the algae and bottom-dwelling plants die, they decay and using up oxygen in the water. This phenomenon leads a condition called hypoxia that they use oxygen concentration in the water and makes

difficult for aquatic organism to survive. In addition to that, hypoxia or Eutrophication may be associated with conditions and the result is in harmful algal blooms and aquatic environments. When fish and shellfish eat harmful algal blooms, they can accumulate toxins, which the algae produce. Consequently, when people eat seafood with algal toxins, they may get sick. Furthermore, it also affects aquatic organisms living environment, loses the balance of aquatic ecosystems as well as dangers to human health.

Agricultural non-point source pollution (ANPSP) has become a global environmental issue due to its widespread dispersion, difficulty in treatment, and delayed impact. Compared with point source pollution, the monitoring, and management of non-point source pollution have proven to be more challenging, particularly at the watershed scale (Tian et al, 2025) because its diffuse sources, unclear origins, and variable and complex (Jiang et al., 2024). ANPSP denotes dissolved or solid pollutants originating from non-specific sources, which are transported by runoff into receiving water bodies such as rivers, lakes, reservoirs, and bays through the runoff process (Hee Shim and Hyun Choi, 2024). Non-point source pollution is therefore characterized not only by randomness and extensiveness but also by latency and lag (Juan Huan et al, 2025). Among these, in the case of non-point source nitrogen pollution, the main source of nitrogen pollution for arable land is nitrogen fertilizer application, and for towns and cities, the main source of nitrogen pollution is domestic sewage (Zhang et al., 2022) all of which are difficult to control compared to point source pollution. Agricultural NPS pollution is the leading cause of surface water impairment across more than 330 million acres of farmland. Similarly, countries such as China and South Korea have devoted substantial research efforts to addressing the impacts of NPS pollution on water quality (Muhammad Awais et al, 2025). Nutrients when present in increased concentrations result in accelerated eutrophication of the water bodies. Water quality affected by excess runoff, sediment, and nutrient losses from agricultural areas can be improved by implementing best management practices (BMPs) that control the movement of NPS pollutant loads. The BMPs can be implemented at a field or farm scale to control NPS loads at the source or to control the transport of pollutants once they have left the source areas (Ritter and Shirmohammadi, 2001).

In establishing process of the best management practices for non-point source pollution, the factors need to be considered as land use, precipitation, forest cover rate, fertilizer, and pesticide because it decides and reveals amount of total nitrogen as well as total phosphorus in the water. Moreover, land use is one of many factors has the most important characteristic because via land use, the researcher can be known the distribution of land use patterns, land use area, land use changing between years. Addition to that, it is also an important data to estimate, simulate, assess non-point source pollution load. From these things, they can be made out

many pieces of advice and the best management practices, which is useful and suitable with different water pollution from non-point source source. Besides, precipitation and forest cover rate usually are considered as well in making out the best management practices for non-point source pollution because big precipitation intensity will increase content of sediment, which is washed away from soil and surface of land, especially when low forest cover rate. If forest cover rate is high, it will be kept a big NPS pollution amount. When runoff after flowing through the forest with high cover rate, it is regarded as a filter and runoff will be become purer. Thus, it will improve runoff and environment. Contrast, with low forest cover rate by cutting trees or changing land use pattern (cultivation...etc.), the runoff not only loads a big NPS pollution amount, but also bring no small number of sediments and other substances, and the runoff or river will be more and more accreted in the future, it will seriously affect to environment and runoff quality. In other words, non-point source pollution is assessed through precipitation because storm water comes, it will bring a non-point source pollution amount into a runoff. Therefore, high or low precipitation volume affects to non-point source load at all. Furthermore, fertilizer and pesticide are two kinds of chemistry, which is been the most using in agriculture development. If it is used right way in agriculture, it is not only useful with plants in cultivating growth but also it is not affected to environment. However, due to social modernization, urbanization, agricultural growth leads to increase amount of fertilizer and pesticide in order to protect crops as well as increases productivities. From that, it increases to residue content of nitrogen and phosphorus in soil, and they are washed away by raining. Using the best management practices is to reduce these nutrients in the water as well as non-point source pollution. Therefore, all the above factors need to be considered carefully for different objectives before applying the best management practices.

Best Management Practice for Non-Point Source Pollution

Non-point source pollution has a significant impact on regional water environments worldwide (Wu et al., 2025). In particular, nonpoint source pollution from agriculture is becoming the major cause of water pollution and lake eutrophication, which has seriously affected the quality of the water environment and the health of the ecosystem, and constrained the sustainable development of the economy and society (Yang et al., 2020). Therefore, management of non-point source pollution has become one of the most pressing challenges worldwide (Ding et al., 2023; Ren et al., 2022). Comparing with point source pollution, influence of factors in non-point source pollution are often more numerous and complex, such as land use type, weather and soil type (Xue et al., 2024). Moreover, fertilizer and pesticide are used in agricultural activities. And the big using amount in agricultural activities leads to increase in nutrient content, including nitrogen and phosphorus. It will affect directly environment, runoff, lake, river, etc. for that reason, non-point

source pollution is more difficult to monitor and quantify than point source pollution (Juan Huan et al, 2025). Thus, making the best management practices to control nutrients in the water, runoff, river and to diminish pollution as well as manage agricultural residues are necessary in non-point source pollution management. And agricultural BMPs can reduce nutrient runoffs, such as nitrogen and phosphorus from farms into water bodies, decrease nutrient impairment in watersheds, and thereby improve water quality (Susannah Cogburn et al, 2026) and mitigate sediment losses.

The best management practices (BMPs) were started from the 1970s. In the 1972, the Federal Water Pollution Control Action in America discovered the best management practices, and the United State Environmental Protection Agency defines that the best management practices are methods, actions, and ways including engineering operation and non-engineering operation (方志发等, 2009), which can be reduced or protected natural resource and environment without being polluted. In this period, England started applying the best management practices in control of agricultural non-point source pollution. This method was gained plenty of success in environmental protection, contemporary set up many other featured methods to protect environment from region pollution. Then, the best management practices were applied wildly in Europe (陈洪波等, 2006). In China, the best management practices are early applied for point source pollution control, then for non-point source pollution, and they almost are referenced from Europe and North America. However, due to geographic feature and economic development are different, application of BMPs in China is not uniform. Some BMPs uses vegetable filters or artificial wetlands. However, the goals of the best management practices are to:

- Minimize pollution reduction in the watersheds and rivers, including agricultural non-point source pollutants
- Promote infiltration
- Removing pollutants from runoff before allowing it to flow into natural receiving waters.

Best management practices (BMPs) can be generally categorized into structural and non-structural control (Wanielista and Yousef, 1993). It is regarded as operation, maintenance (Mostaghimi et al. 1997), and management procedures, in which non-structural controls prevent polluted problems in the environment by reducing potential pollutants or manage runoff at the source, all those are to decrease possible impact on the water body. This control can take the form of regulatory as codes, ordinances, regulations, standards, or rules. It has tended to less costly as well as easier to design and implement than structural BMPs. Non-structural BMPs normally do not have technical or engineering designs associated with them; therefore, it can be quickly modified to take advantage of new

opportunities or adapt to environmental conditions. Non-structural controls can be used in land use control and source control that their aims are to reduce or prevent pollutants at their source before coming into contact with runoff or land use, such as educating citizens in protecting environment or instruction of fertilizers and pesticides using ways in standard. Contrast, structural controls manage and monitor polluted source, from that it can control polluted emission volume, peak discharge rate to improve environmental quality. Structural control is more expensive and difficult than non-structural control because it needs to invest for treatment or removal pollutants exist in the environment. In addition to that, it is also based on pollution control and approaches can be classified into three groups: first is to control pollutant on site (minimization of pollution generation); second is to collect or reduce pollutant substances delivery to the receiving water body; and third as treating the runoff (Novotny and Chesters, 1982; Claphamm et al. 1999), or in soil erosion control, BMPs is often used to prohibiting certain land use activities on hazardous lands, prevent topsoil loss from erosion enhancement of infiltration and surface water storage of the land, and reduce contaminant levels in soil and imperious surfaces.

With non-point source pollution management, BMPs can be control, prevent, removal contamination, which enter water body and make reducing pollution, especially is non-point source pollution. However, to apply successful BMPs for non-point source pollution, researchers need to consider the natural conditions of the study area, land use types, the type of pollutants and climatic environment and other factors. Besides, BMPs for NPS pollution management are also divided into two types: preventive practices and remedial practices. Prevention refers to not creating or at least minimizing the probability of creating that this practice is to prevent polluted substances release into water bodies. One of the widest applications is management of non-point source pollution. There are several available methods to reduce the emission of the nutrient into the river system as close management of the agricultural chemical using via managing system and cost of product. However, preventive practices are often the most logical and economic defenses and somewhere can be applied in preventive practices alone, but it will not be adequate to keep the fresh environment from non-point source pollutant. Application of polluted treatment method by technologies usually is used in remedial practices, such as removal of pollutants by sedimentation and infiltration or enhancement of vegetation cover because it is an excellent source control method, it can protect the surface land and reduce runoff.

Best management practices (BMPs) are important measures for watershed pollution control. The focal points lie in achieving the effect of purifying pollutants through the detention of runoff in ponds, lake, and wetland ecological system. Constructing riparian buffer strips and artificial wetland are to absorb the agriculture runoff. Riparian buffer strip includes grass and forest could effectively hold up

pollutants, contemporary increasing vegetation coverage to improve the regional environment. The artificial wetland is used to purifying wastewater via intercept, adsorption, and precipitation, which has a better removal effect of nitrogen and phosphorus. Moreover, it will make diminishing of flow velocity and petroleum hydrocarbons, and nutrients as nitrogen and phosphorus can be taken by plants in these wetland sub-basins. In addition to that, artificial wetland has the advantages of low investment, simple technology, high resistance ability to non-point source pollution load and the remarkable ecological environment benefit. It is also suitable in rural areas with rich land resources. When rainfall is large, storm accumulation pond and stabilization pond could store runoff sewage, then the accumulation pond is mainly used for the temporary storage of runoff and stabilization pond is mainly used for processing and purifying runoff. Moreover, decreasing exposure of nutrients is to diminish nitrogen and phosphorus content into flows and water body. Especially, in forest land area with the steep slope, vegetated buffer strips are able to enhance stability of soil surface, increase osmotic level with flow volume, remove nitrogen and phosphorus pollutants, and impede transport of nutrient-enriched sediment and particulates.

- **Agricultural Runoff Control BMPs**

Agricultural runoff is most paid attention in non-point source pollution control BMPs because non-point source pollution is originated mainly from agricultural activities. In order to be able to control agricultural runoff by the best management practices, this runoff needs to be collected in biological channels to avoid flowing spread on the surface ground, contemporary bringing runoff to bio-retention pond. Bio-retention Pond is formed by water and treatment plants of pollutants. Agricultural runoff is flowed and it stays for a short time. While this time, pollutants are deposited under a pond bed and treated by organism. Therefore, it is designed to capture whole pollutants in runoff and it has high effectiveness in removing pollutants. Water after flowing through bio-retention pond becomes less pollution, but this runoff needs still to flow through vegetated buffer or vegetated swale to gain water, which can be reused. Vegetated buffer is a buffer including plant strips in different density, such as trees and grasses. Vegetated swale is similar as well. It only differs from the vegetated buffer as concluding shrubs and its runoff is swales. Their capacities are the same. They receive all the polluted runoff and filter pollutants to reduce runoff pollution. Outflow can be reuse for irrigation in agriculture.

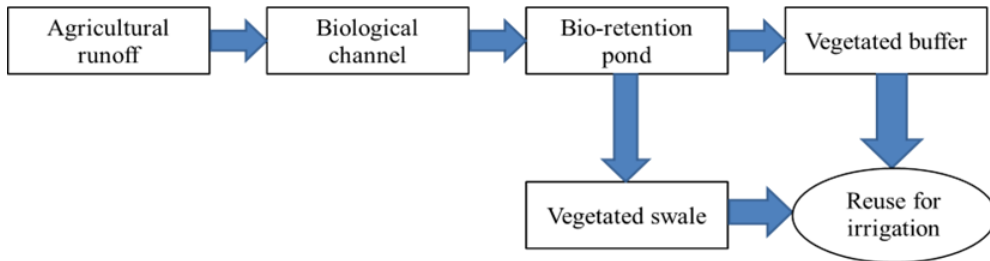


Fig. 2: BMPs for NPS pollution control in agricultural runoff

However, when agricultural runoff with big volume in storm water season, it also brings a big amount of non-point source pollutants, so it needs to be treated in distinguished condition. It means this runoff needs to be collected quickly in a storm drain channel before flowing into a retention pond. In retention pond, runoff is captured and pollutants are removed as well. Next, it runs through vegetated swale and grass buffer to filter and keep pollutants. Especially, grass buffer includes turf grass in uniform density. This significant helps runoff to flow easier, but ensure the pollutants are still removed, and the water is gained after using this best management practice can be reused for irrigation. Another measure to NPS control in agricultural runoff under storm condition is to storm water runoff flows spread on porous pavement with infiltration before coming into riparian buffer restoration. On porous pavement with infiltration, runoff will infiltrate through sand filter media and plants. Restoration will keep runoff left to deposit sediments, and then it is filtered via a constructed filter. This is an excavated area, which is constructed by a layer of sand, compost, organic material, plants to reduce the pollutant level of storm water runoff. Finally, out of runoff can be used for irrigation as well.

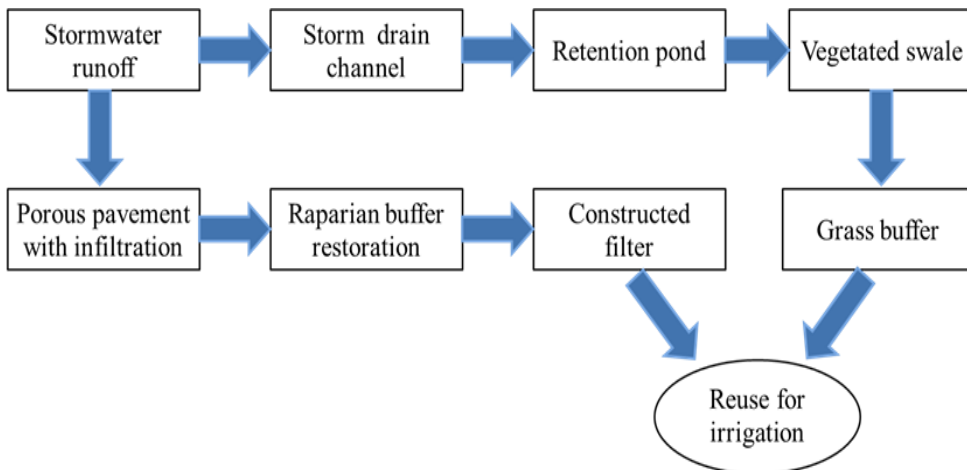


Fig. 3 BMPs for NPS pollution control in agricultural runoff under storm condition

- **Urban runoff control BMPs**

Urban runoff is second paid attention in non-point source pollution control by the best management practices. It needs to be collected in the constructed channel before runoff flows into landscape restoration. The constructed channel is designed by artificial construction to bring runoff into restoration. In restoration, the runoff decreases velocity and other substances will be deposited under restore bed. Then, water is drained through the vegetated roof and the vegetated filter strips. In these systems, the whole pollutants as sediment and other pollutants from urban are leached by plants, and outflow can be gained as landscape water.

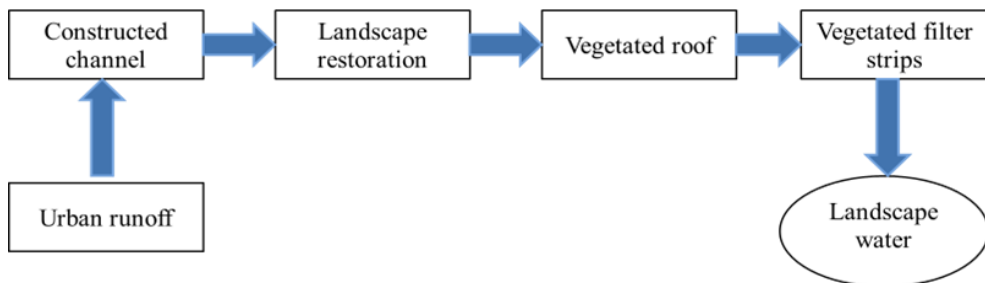


Figure 4: BMPs for NPS pollution control in industrial runoff

- **Building runoff control BMPs**

Building runoff usually appears at urban development area, where concludes many construction regions and building runoff includes not only non-point source pollutants, but also has many sediments. Therefore, the best management practice for this runoff is diminishing pollutants quickly at first step. Moreover, the runoff needs to flow through the vegetated roof or soil amendment restoration. Vegetated roof or green roof is designed by a thin covering of vegetation, waterproofing, synthetic insulation, non-soil engineered growth media, fabrics, synthetic components, and foliage to decrease runoff velocity and filter harsh components. Different from the vegetated roof, the runoff is not filtered through vegetated cover, it is flowed into soil amendment restoration to not only decrease runoff velocity but the pollutants are also filtered by deposition and plants. Next, runoff is leached into constructed wetland to filter pollutants again by aquatic plants and slow down runoff and allow time for settling out sediment and biological uptake. In another practice, runoff after staying in soil amendment restoration is leached via constructed wetland channel, which is designed by constructed swales and aquatic plants, such as rushes, willows, cattails, and reeds. Then, the runoff of two systems is flowed through vegetated buffers to enhance infiltration, filter, and removal of runoff contaminants. The outflow is used as landscape water in this BMP measure.

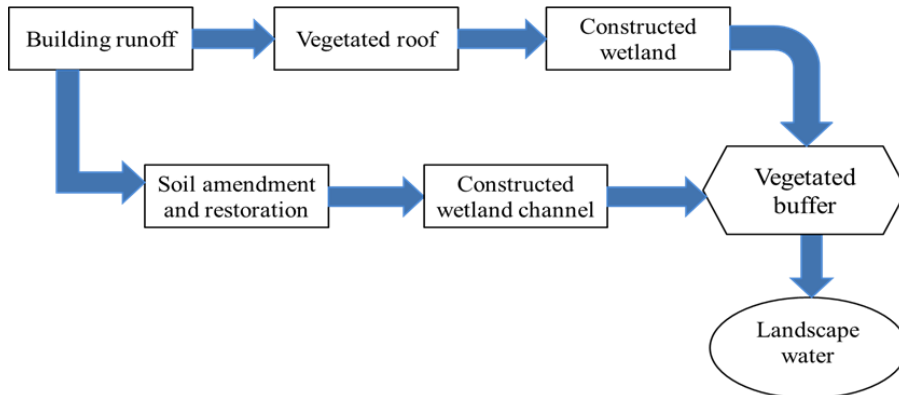


Fig. 5: BMPs for NPS Pollution Control in Building Runoff

- **Oil/Grease Runoff Control BMPs**

Oil and grease runoff is originated from industrial activities and it is a kind of runoff, which is difficult to treat because rainfall runoff will bring not only non-point source pollution, but also include oil and grease release from industrialization. It needs to be separated out other runoffs to control easier. Therefore, Oil and grease runoff need to be collected in especial private area to catch them, that is oil and grease catch pond. Runoff is collected in this pond and its aim as separate oil and grease out flowing. Next, runoff left will flow into soil amendment restoration and dry well to continue leaching oil and grease. Then, runoff flows into the extension detention pond. This is a wet pond includes water and treatment plants. It can capture plenty of pollutants and remove pollutants. Finally, runoff is filtered in vegetated filter strips, which is made by grass surfaces to enhance infiltration and remove runoff contaminants.

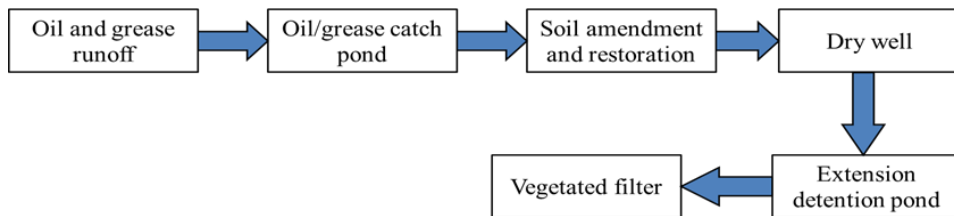


Fig. 6: BMPs for NPS Pollution Control in Oil/Grease Runoff

- **Road Runoff Control BMPs**

Runoff on the road is also rolling non-point source pollution via rainfall. In order to do the best management practices for this runoff, the study exposes two measures. The first measure, road runoff is kept in pavement detention pond to leach harsh substances on the road and deposits suspend substances before running through vegetated strips. In vegetated filter strips, strip of vegetation is designed to

slow runoff velocity, filter out sediment and other pollutants. The second measure is road runoff will be flowed on the vegetated roof before it is into grassy buffer through constructed wetland channel. Vegetated roof is designed including a thin covering of vegetation on the roof to water can be infiltration quickly and harsh substances also are kept. The pollutants will be leached mainly at grassy buffer and a small part is filtered in constructed wetland channel. Especially in these two measures, the runoff is filtered in grassy buffer, which is made turf grass on the surface with different density and outflow after leaching can use as landscape water.

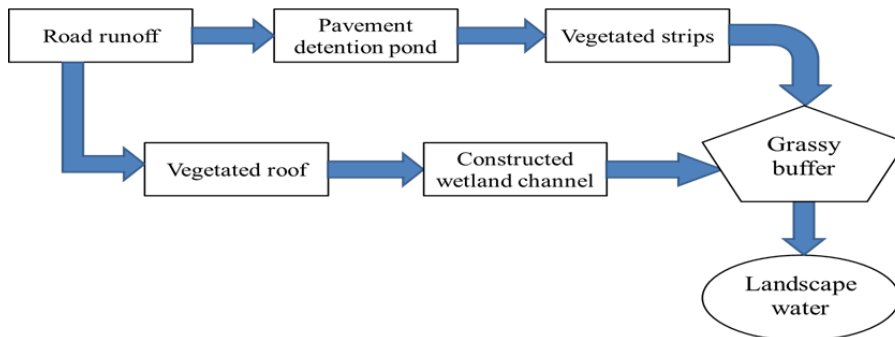


Fig. 7: BMPs for NPS Pollution Control in Road Runoff

- **Forest Runoff Control BMPs**

Forest runoff brings non-point source pollution is usually treated in natural condition. The best management practice for NPS control in forest runoff is often used available materials in the forest, for example in this measure; forest runoff is collected in wetland channels/banks in the forest before it flows into the natural wetland. Then, it continues leaching in the vegetated buffer. In every step of this measure, the runoff is filtered through vegetated classes in different kinds, such as plant shrubs in the channel; aquatic plants in the wetland; and grassy plants in the buffer. They will help runoff become fresher by being removed out non-point source pollutants and other pollutants. Water after filtering in vegetated buffer can be reused for irrigation or like landscape water.

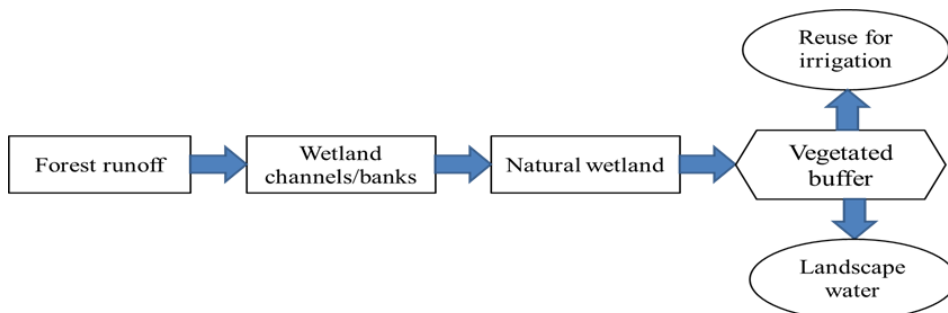


Fig. 8: BMPs for NPS Pollution Control Of forest Runoff

Conclusion

In this chapter provide reader to understand about non-point source pollution, best management practice, and control for non-point source pollution via the best management practices. The best management practices are proposed to reduce nutrients and control non-point source pollution as 1) Agricultural runoff needs to be controlled by bio-pretention method via pond and vegetated buffer or vegetated swale after non-point source pollution runoff is collected in biological channel. In storm condition brings a big amount of non-point source pollution, runoff needs to be flowed through riparian buffer restoration or storm drain channel to reduce runoff velocity before conducting to be filter. 2) Urban runoff includes normally nutrients from roads, highways, and bridges. From that, this kind of runoff needs to be passed many filtered buffers as vegetated filter under roof or strip form. 3) Building runoff usually appears at urban development area, where concludes many construction regions and building runoff includes not only non-point source pollutants, but also has many sediments. Therefore, this runoff needs to reduce quickly sediments in first stage via restoration or vegetated roof. Moreover, with building runoff needs to be constructed wetland stores to keep nutrients from non-point source pollution and left sediments after first filter stage. 4) Oil/grease runoff brings contaminants from industrialization process; it needs to be treated in soil amendment and restoration as well as dry well to keep big amount of grease in runoff. 5) Road runoff is designed by some filter classifications as vegetated strips or roof, wetland channel, especially grassy buffer because this runoff is accumulated by a complex mixture of contaminants as organic compounds, roadside sediments, nutrients, pathogens, and microplastics. 6) Natural wetland, wetland banks, and vegetated buffers are useful the best management practices for controlling non-point source pollution with forest runoff.

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