Comprehensive Renovation Plan for Water Environment of Lujiabang River

Shanghai, China

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Abstract

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Abstract

The thesis is focused on the problem of ecology or rather the water pollution problem. Nonpoint source pollution (NPS) is considered. As it is already known water pollution is currently one of the most urgent issues around the world. Contaminated water fatally influences on health of population and may lead to the death of fish, waterfowl and other animals, as well as to the destruction of flora of reservoirs.

Thus, the primary goal of the thesis was to figure out NSP pollution sources to plan the effective methods in order to improve the quality of water conditions.

The project itself includes observing Lujiabang River, visiting organization called "浦东水文水资源管理暑" ("Shanghai Pudong Hydrology and Water Resource Administration"), analysing data and making a research.

The main part of the project was to plan the management process of the implementation methods regarding water pollution based on the collected data, personal study, research material, knowledge and experience.

Keywords
Planning, Management, Environment, River, Water, Pollution, Contamination, COD, SS, T-P, T-N, Ammonia, Nonpoint source pollution (NPS), Runoff, Sewage, Pump station

Public

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ABBREVIATIONS

As	Arsenic
BOD	Biochemical Oxygen Demand
C_6H_6O	Phenol
C_7H_8O	Volatile Phenol
Cd	Cadmium
CN^-	Cyanide
COD	Chemical Oxygen Demand
Cr	Chromium
CSS	Combined Sewer System
CTC	Number of critical indicators of water pollution
Cu	Copper
DO	Dissolved Oxygen
EHP	Extremely High Pollution
F	Fluoride
Fe	Total Iron
GB	National Mandatory Standards - Sequence number and national standards issued by the national standard reign ID code, the national standards published (using the last two digits of the year of release) composition.
GB3838-2002	Surface Water Environmental Quality Standards
GHZB	Environmental Quality Standard for Surface Water
Hg	Mercury
HP	High Pollution
Mn	Manganese

MPC	Maximum Permissible Concentration
MPD	Maximum Permissible Discharge
NH_3	Ammonia
Ni	Nickel
$N\text{-}NH_3$	Ammonia Nitrogen
$N\text{-}NO_2$	Nitrite Nitrogen
$NO_3\text{-}N$	Nitrogen Nitrite
NPS pollution	Nonpoint source pollution
Pb	Lead
pH	Potential of Hydrogen
R&D	Research and Development
RD 52.24.643-2002	Method of integrated assessment of the degree of contamination of surface water on hydro-chemical indicators
S_2	Sulphide
SDS	Sodium Dodecyl Sulphate
Se	Selenium
SON	State Observation Network
SS	Suspended Sediment
T-N	Total Nitrogen
T-P	Total Phosphorus
UKIZV	Specific combinatorial index of water pollution provisionally estimates the share of polluting effects, contributed to the overall extent of water pollution caused by the simultaneous presence of a number of pollutants
Zn	Zinc

1 INTRODUCTION

Nonpoint source (NPS) pollution is mainly affected by precipitation conditions. Rain washes the ground and takes urban runoff together with solid and dissolved contaminants causing pollution of water bodies. Urban ground contains many polluting substances: solid waste debris, chemicals, air subsidence, vehicle emissions, roof sediments and precipitates. The rapid development of urbanization and construction of cities changes the cities' surface environment by increasing the hardening rate of the surface by enlarging the proportion of impermeable, so that urban surface runoff cannot penetrate the soil or plant closure and can be led out from the roads only through combined systems or shunt systems causing significant river pollution. In the developed countries nonpoint source pollution has become the first factor of water pollution, the cause of 60% of water pollution is from rain runoff.

For a long time, China has been facing serious pollution problems of industrial wastewater and urban sewage. During this time Chinese government was focused on point source pollution (industrial waste water) and nonpoint source pollution mainly for rural farming area contaminated soil erosion surface sources. However, the surface water pollution of urban nonpoint source started only in 1980s. That is why it has not been well studied yet and there is lack of monitoring information system. Therefore, research and characteristics of urban nonpoint source pollution laws can provide a scientific basis for the government point pollution control management decisions.

The thesis is focused on contamination of Lujiabang River, flowing in Pudong New Area of Shanghai, China. Nonpoint source pollution, specifically rain runoff and sewage, are taken into consideration. The thesis is aimed at finding out the NPS pollution effect, its reasons, and at planning the methods in order to increase the water quality conditions by controlling and preventing this source of pollution.

2 THE WATER QUALITY MEASUREMENTS IN PUDONG AREA

This part involves all the collected data for further research, based on the following issues:

1. Geographical situation of Lujiabang River;
2. Investigation of natural precipitation and monitoring of water quality;
3. Investigation of rain water in the river before rain runoff touches the water surface;
4. Monitoring the impacts of surface runoff to the river water quality;
5. Investigation of the quality of water leaked through the ground and the quality of water after it fell to the river.

2.1 Lujiabang River, Shanghai, China

Lujiabang River, also called Zhaojiabang River, was built in 1861. The length of the river is about 2.44 km. The river flows in Kangqiao area, located in Pudong New District of Shanghai, China (Figure 1). West side of Lujiabang River started from Puzhao River, East side goes to Huangpu River. There are eight bridges above Lujiabang River. They are Xie Bridge, San Guan Bridge, Guang Dong Bridge, Fang Sheng Bridge, Pu An Bridge, Hai Chao Temple Bridge, Wan Ning Bridge. Prior to the twentieth century, land transportation was not developed, so Lujiabang River played an important role in transportation. By the early twentieth century, with the construction of modern roads, there was the development of road transport vehicles, so inland waterway transport is gradually shrinking.

Even though Lujiabang is a comparatively small river in Pudong area, it brings the impact on other rivers, which are flowing into Yangtze River. Yangtze is the longest river in Asia and the third-longest in the world.

FIGURE 1. Map of Lujiabang River (Google maps, 2015)

The pumps station of Lujiabang River, called Gong Yuan Shan Cun Pump Station is combined pump station (Figure 2). It means that it combines water runoff and municipal waste water, which was discharged into Lujiabang River.

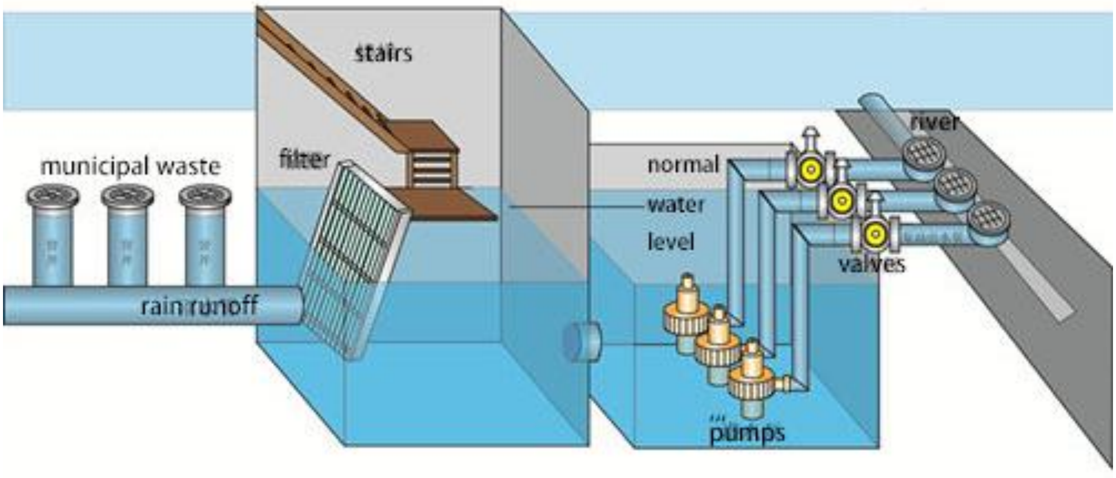


FIGURE 2. Combined pump station (China Zhejiang Channel Network Analysis, 2014)

2.2 Pollution sources to be considered

Pudong New Area is located on the coastal side of China which creates its advantage for sustainable development of socio-economic constraints. Even though the district continued to increase river regulation efforts, nowadays water pollution and water environment are the biggest obstacles to further development of Pudong area. As the main factors that affect the river water quality have not been cleared out, there is an urgent need to study the impact of influence of pumping the initial rainwater on river water quality, as well as the impact of natural precipitation on the water quality of rivers, including analysing of river water quality after filtration through the soil. Thus in 2013-2014 Pudong New Area Hydrology Department together with Second Polytechnic University established cooperation for developing a research on the effects of surface runoff on river water quality in order to evaluate its effect on river water quality. This report includes studying and measuring the common contaminants in the surface runoff, such as suspended solids (SS), chemical oxygen demand (COD), ammonia nitrogen (N-NH_3), total phosphorus (T-P), total nitrogen (T-N).

2.3 Status data on water quality

This part represents the data got from “Shanghai Pudong Hydrology and Water Resource Administration” and describes water quality environment of rivers running in Pudong area, Shanghai, China.

2.3.1 River water quality

The data from Water Environment Monitoring Centre at Pudong New Area is used as a typical case for study the impact of urban nonpoint source pollution on rivers. Monitoring results of Caojiagou, Zhangjiabang and Zhaojiagou Rivers in 2013 and 2014 are shown in the figures 3 to 5.

- SS level was 50-100 mg/L (up to 1378 mg/L of the individual outlets in a single month). The average is 72.5 mg/L.
- The concentration of COD was in range of 5-40 mg/L, with an average of 14.7 mg/L.
- T-N concentration 1-15 mg/L (up to 25.0 mg/L of the individual outlets in a single month), the average is 4.1 mg/L.
- N-NH_3 concentration in 0.1-8 mg/L (up to 22.3 mg/L of the individual outlets in a single month), the average is 1.5 mg/L.
- T-P concentration is 0.02-0.5 mg/L (individual outlets in a single month reached 2.66 mg/L), with the average 0.2 mg/L.

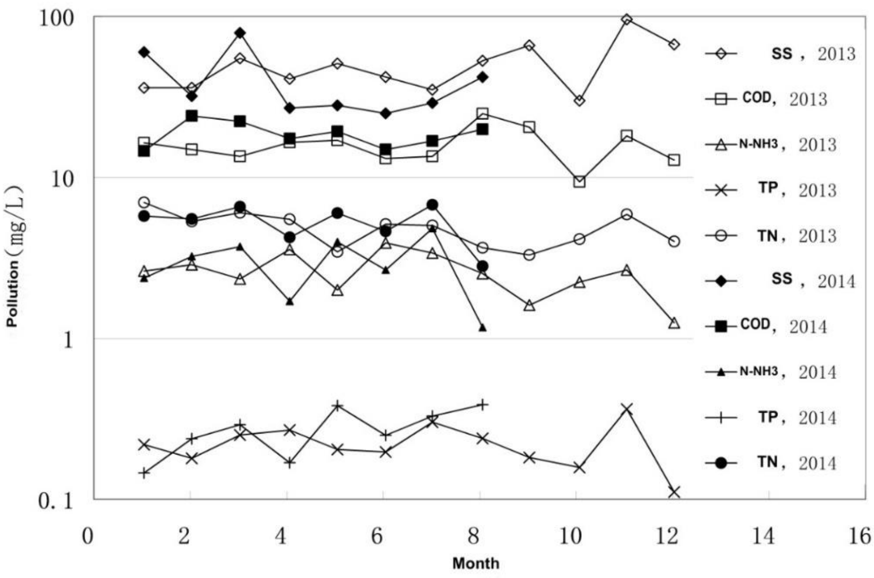


FIGURE 3. Pollutant concentration monitoring network of Caojiagou River (Research Report, 2013-2014)

Figures 3-5 show the results of the concentration of pollutants in the river, Pudong New Area, 2014 (SS, COD, N- NH_3, T-P, T-N), the numbers are similar to year 2013.

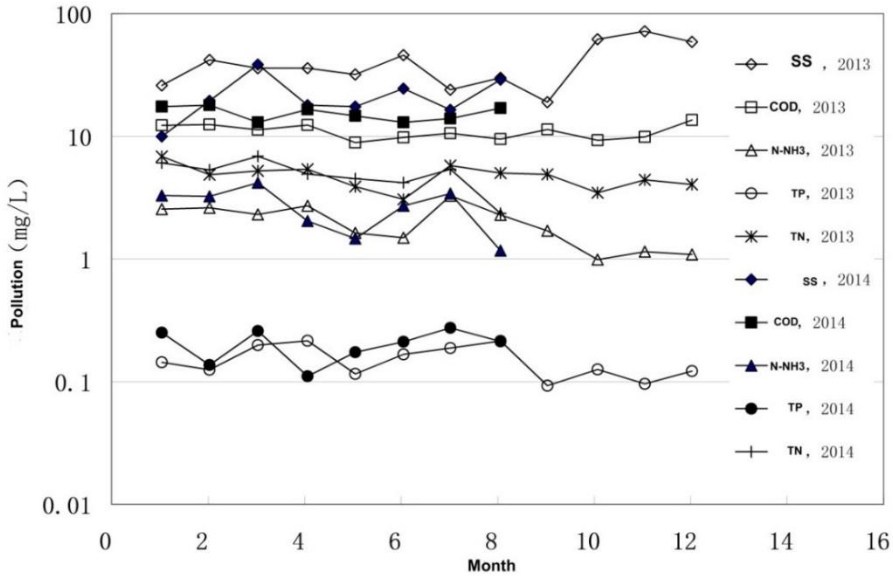


FIGURE 4. Pollutant concentration monitoring network of Zhangjiabang River (Research Report, 2013-2014)

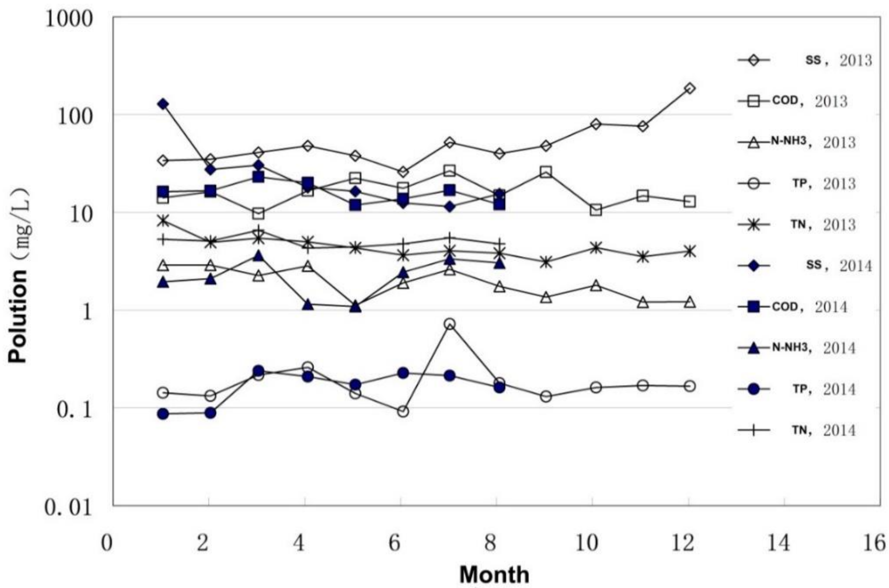


FIGURE 5. Pollutant concentration monitoring network of Zhaojiagou River (Research Report, 2013-2014)

Figure 6 compares the results of COD value provided by Pudong New Area Surveillance River Monitoring Network Station with Surface Water Environmental Quality Standards (GB3838-2002), when COD is taken as an index for analysing rivers in

Pudong area. The majority of rivers' surface water quality in Pudong area varies between I-III levels by concentration of COD and there are few rivers with a COD value belonging to IV and V levels.

Figure 7 compares the results of T-N value provided by Pudong New Area Surveillance River Monitoring Network Station with Environmental Quality Standards for Surface Water (GB3838-2002), when T-N is taken as an index for analysing rivers in Pudong Area. The majority of rivers' surface water quality in Pudong area belongs to level V by concentration of T-N and there are few rivers with results between levels II-IV.

Figure 8 compares the results of N-NH_3 value provided by Pudong New Area Surveillance River Monitoring Network Station with Environmental Quality Standards for Surface Water (GB3838-2002), when N-NH_3 is taken as an index for analysing rivers in Pudong Area. The majority of rivers' surface water quality in Pudong area varies between levels II-IV by concentration of N-NH_3.

Figure 9 compares the results of T-P value provided by Pudong New Area Surveillance River Monitoring Network Station with Environmental Quality Standards for Surface Water (GB3838-2002), when T-P is taken as an index for analysing rivers in Pudong Area. The majority of rivers' surface water quality in Pudong area varies between levels II-IV by concentration of T-P.

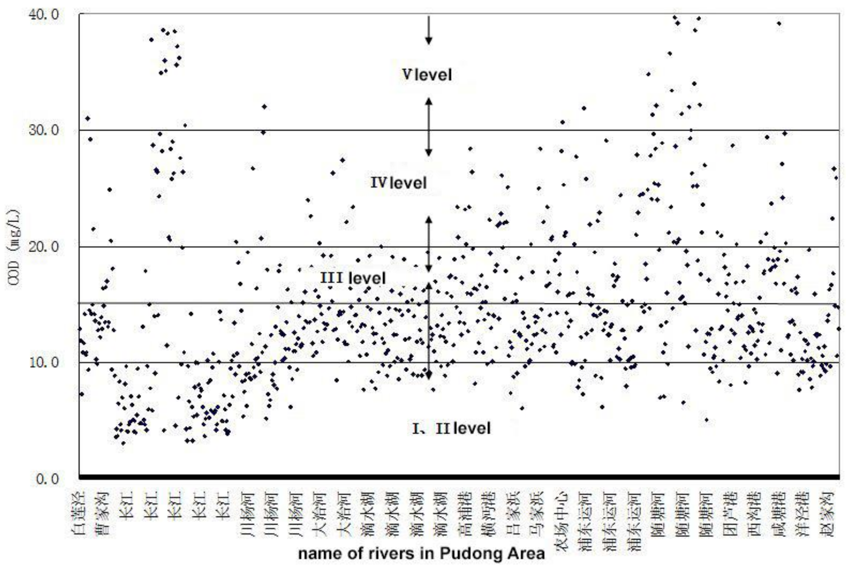


FIGURE 6. Comparison of the results of COD provided by Pudong New Area Surveillance River Monitoring Network Station with Surface Water Environmental Quality Standards (GB3838-2002) (Research Report, 2013-2014)

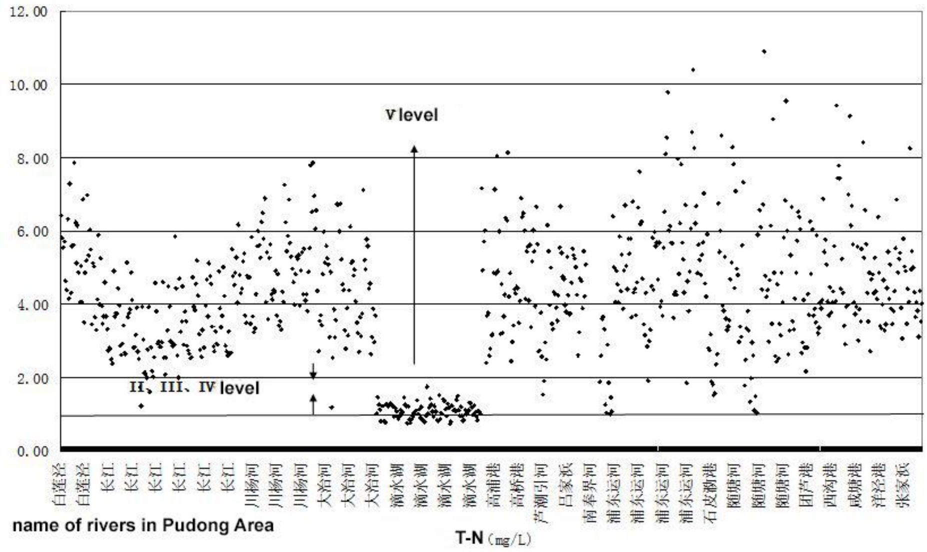


FIGURE 7. Comparison of the results of T-N provided by Pudong New Area Surveillance River Monitoring Network Station with Surface Water Environmental Quality Standards (GB3838-2002) (Research Report, 2013-2014)

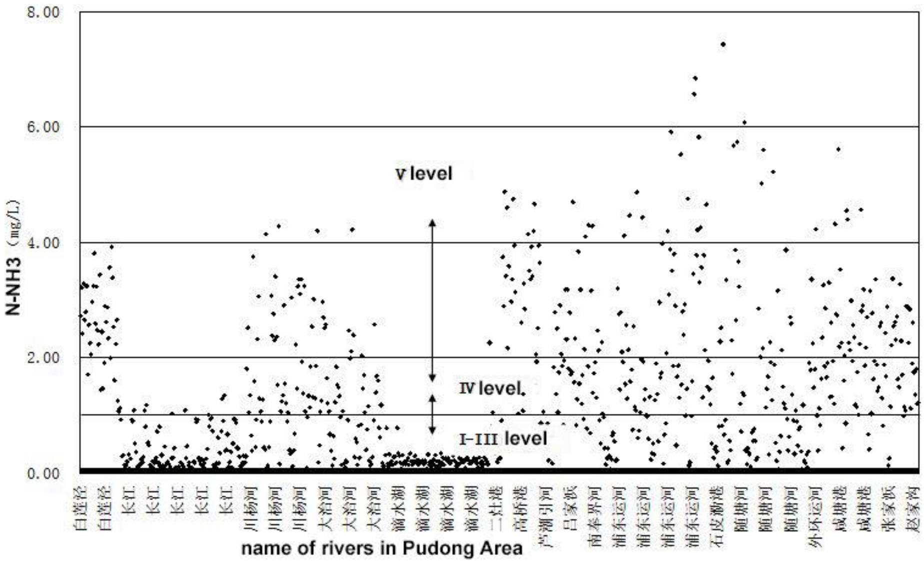


FIGURE 8. Comparison of the results of $N\text{-}NH_3$ provided by Pudong New Area Surveillance River Monitoring Network Station with Surface Water Environmental Quality Standards (GB3838-2002) (Research Report, 2013-2014)

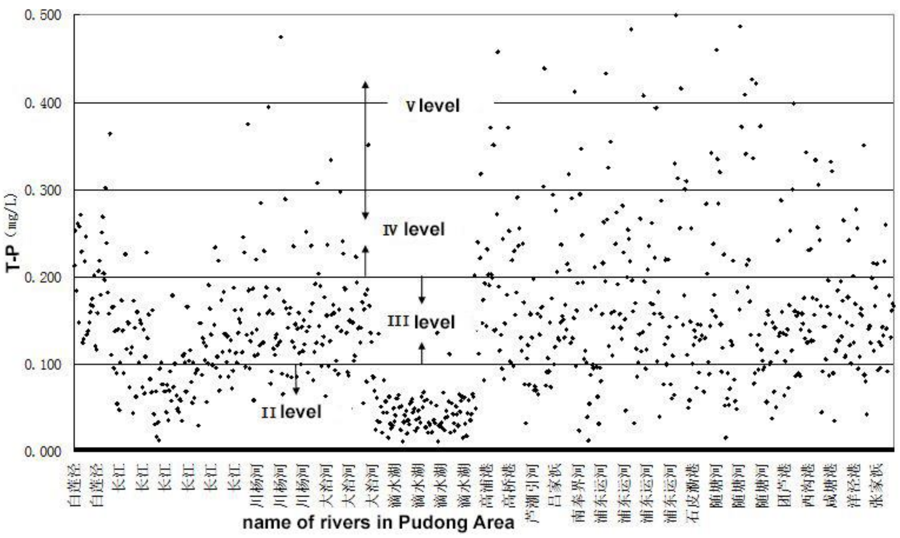


FIGURE 9. Comparison of the results of T-P provided by Pudong New Area Surveillance River Monitoring Network Station with Surface Water Environmental Quality Standards (GB3838-2002) (Research Report, 2013-2014)

2.3.2 Effect of rain on river water quality

Figures 10-14 represent the pollutant concentration measurements made in different weather conditions: before rain, during the rain and after the rain. Caojiagou River is taken as an example to demonstrate the typical values of pollutants. The figures show that on a rainy day the pollution is higher than it is before rain.

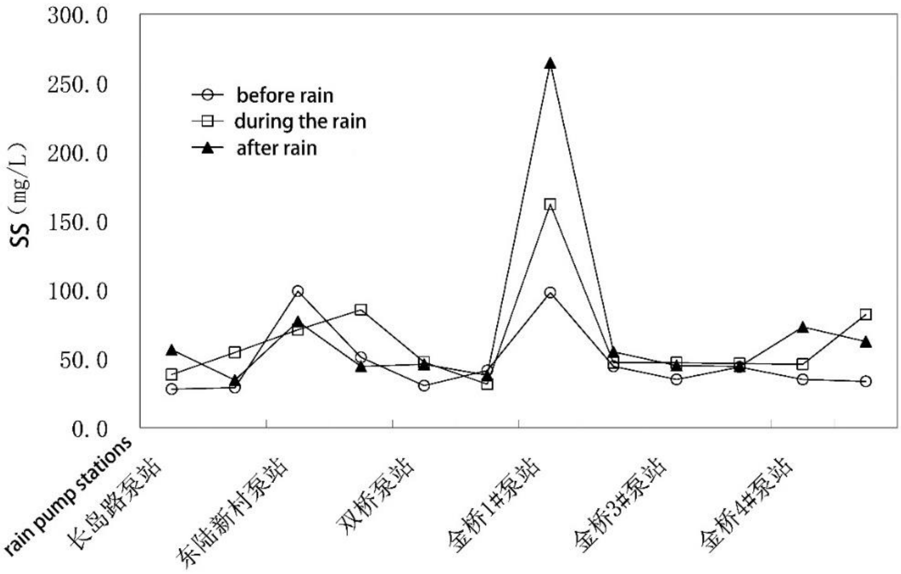


FIGURE 10. Influence of runoff on Caojiagou River, SS results (Research Report, 2013-2014)

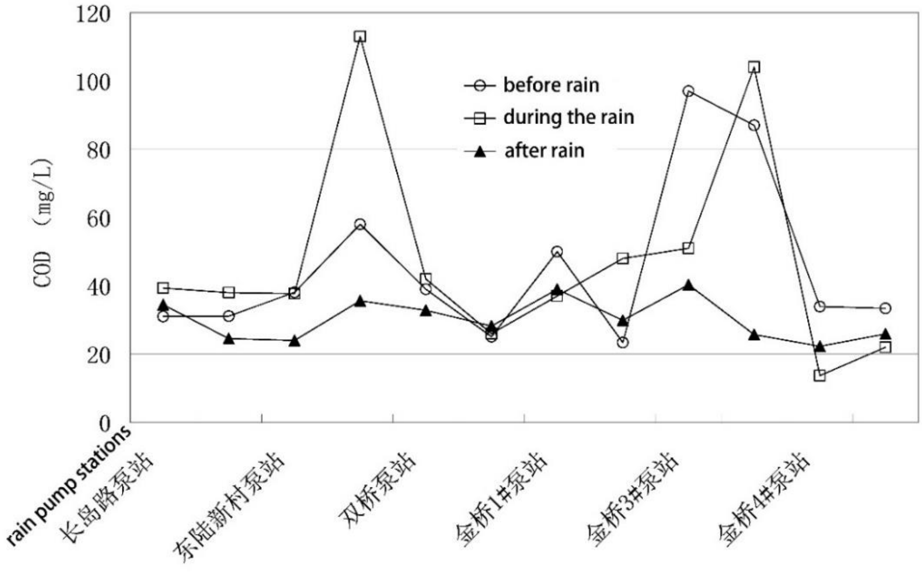


FIGURE 11. Influence of runoff on Caojiagou River, COD results (Research Report, 2013-2014)

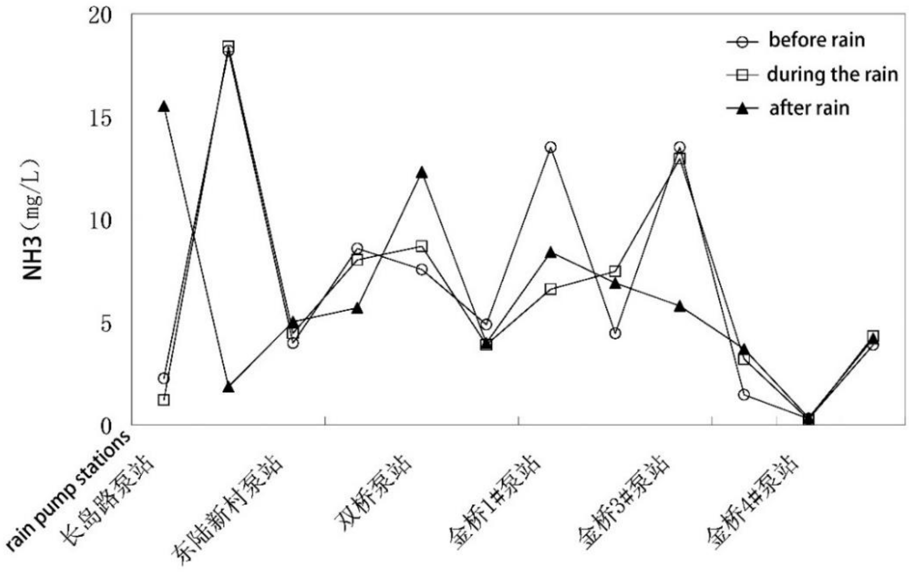


FIGURE 12. Influence of runoff on Caojiagou River, NH_3 results (Research Report, 2013-2014)

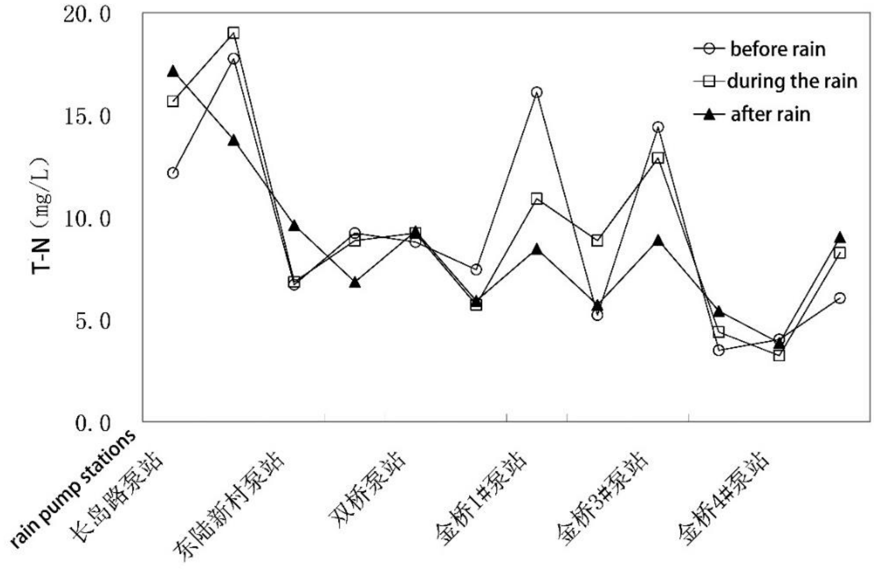


FIGURE 13. Influence of runoff on Caojiagou River, T-N results (Research Report, 2013-2014)

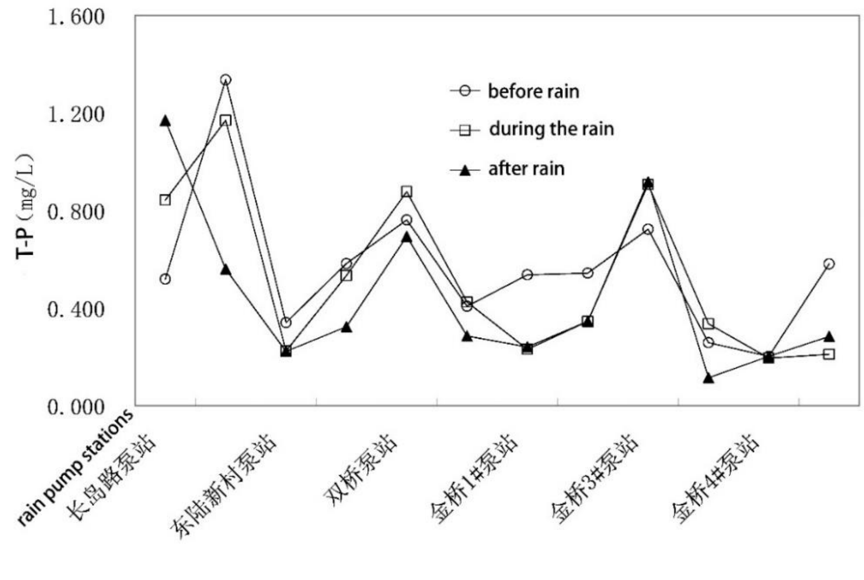


FIGURE 14. Influence of runoff on Caojiagou River, T-P results (Research Report, 2013-2014)

2.3.3 Water quality of rainfall

COD, T-N, N-NH_3 and T-P values of rainfall water in Pudong area are shown on the Figures 15-17. The average value of COD in rainfall water is 5.55 mg/L, reaching the Environmental Quality Standards for Surface Water (GB3838-2002) of COD, level I. The value of T-N varies between 0.17-3.84 mg/L, with an average of 1.34 mg/L, reaching the Surface Water Environmental Quality Standards (GB3838-2002) of T-N, level V. The maximum value of N-NH_3 is 1.62 mg/L, reaching the Environmental Quality Standards for Surface Water (GB3838-2002) of N-NH_3, level IV. The maximum value of T-P is 1.08 mg/L reaching the Surface Environmental Quality Standards for Surface Water (GB3838-2002) of T-P, level III.

That means that rainfall is highly concentrated by T-N and N-NH_3. The air of Pudong New Area is polluted by nitrogen oxides, and belongs to the oxidation air pollution; vehicle exhaust is the main type of air pollution.

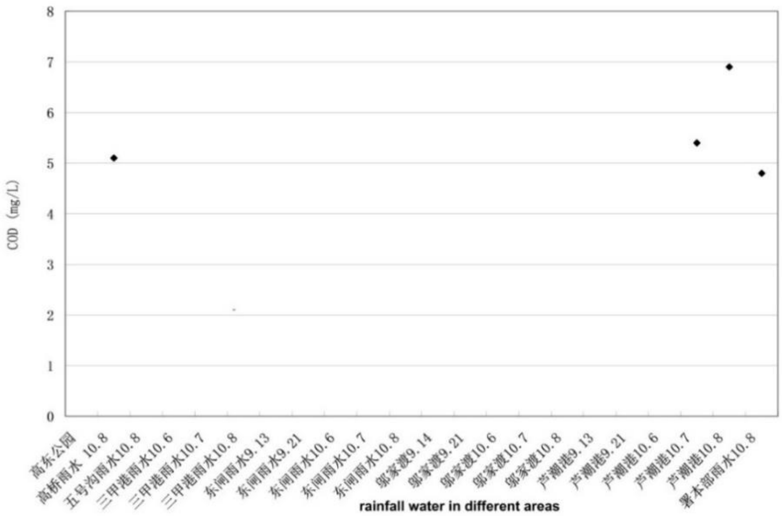


FIGURE 15. Test results of COD in rainfall in Pudong New Area (Research Report, 2013-2014)

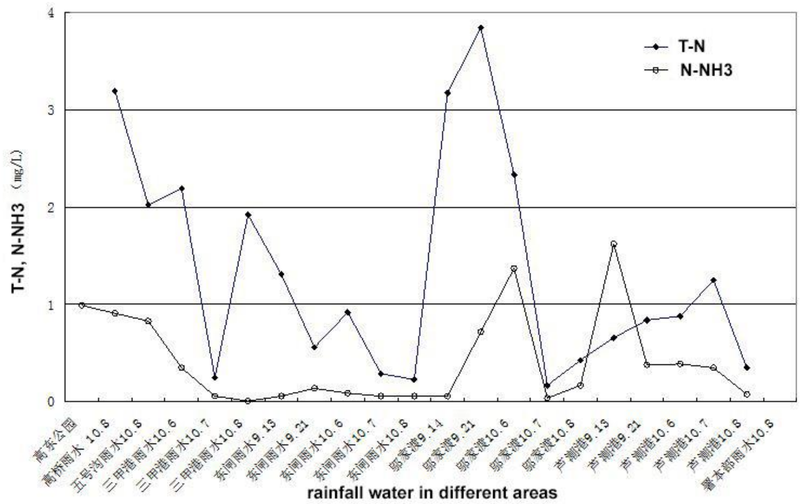


FIGURE 16. Test results of T-N and N-NH_3 in rainfall in Pudong New Area (Research Report, 2013-2014)

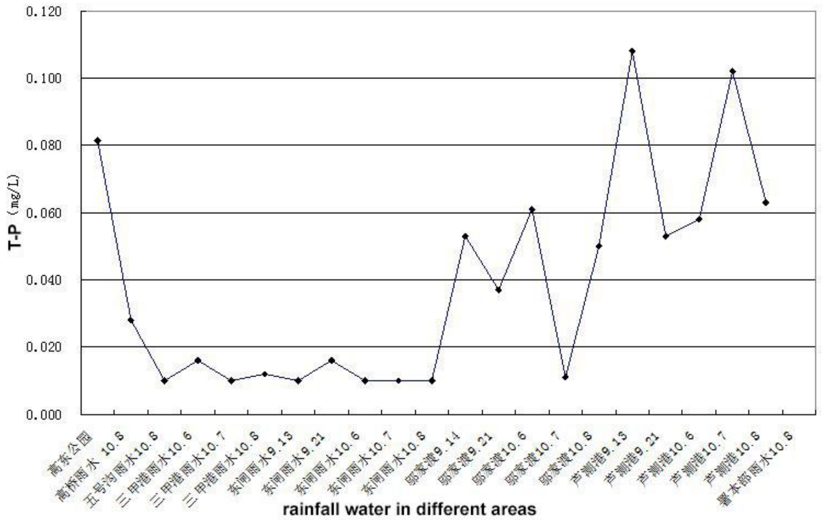


FIGURE 17. Test results of T-P in rainfall in Pudong New Area (Research Report, 2013-2014)

2.3.4 Water quality of water in pump station

The pump station is a complex system for pumping water from one place to another. The rain pump station, which is considered, pumps the runoff water from the streets. This pump station includes building and equipment: pumps (working and reserve) - pumps, piping and auxiliary devices (e.g., valves).

On rainy day all the rain water gathers together and comes to the sink, which collects all the runoff water and sewage from the streets. However, the water needs to be discharged, so it goes to the pump station and is finally pumped out into the river (Figure 18).

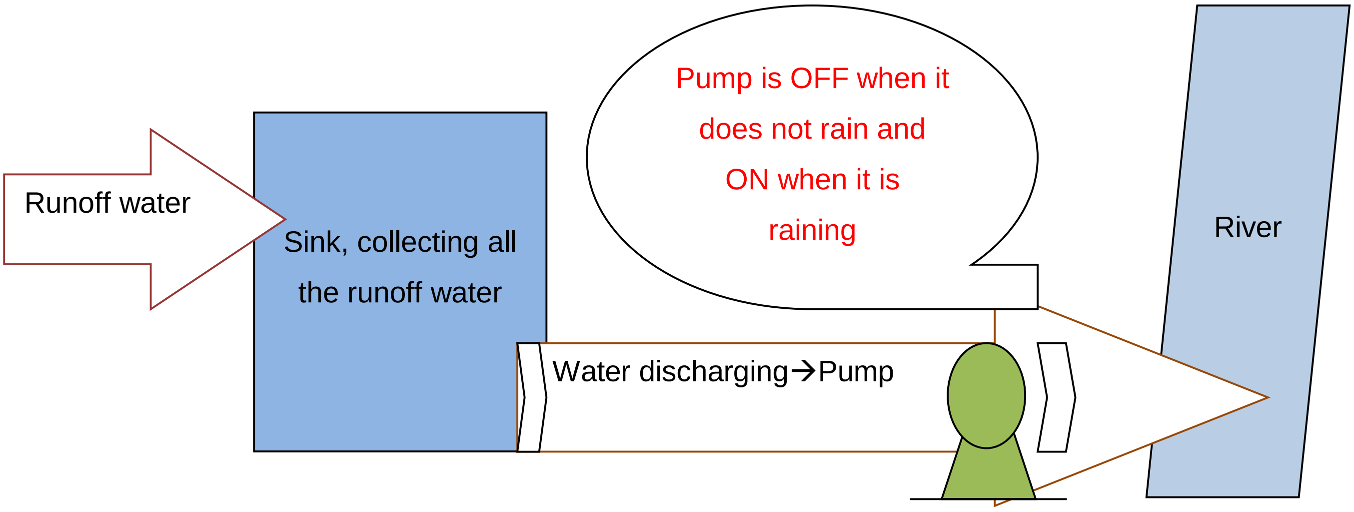


FIGURE 18. The systematic way of water runoff

2.3.4.1 Rain pump station (on a not rainy day)

In the figures below (Figure 19-24) there are shown the results of different chemical components consisted in water. All the samples were taken on a not rainy day from the rivers running in Pudong area.

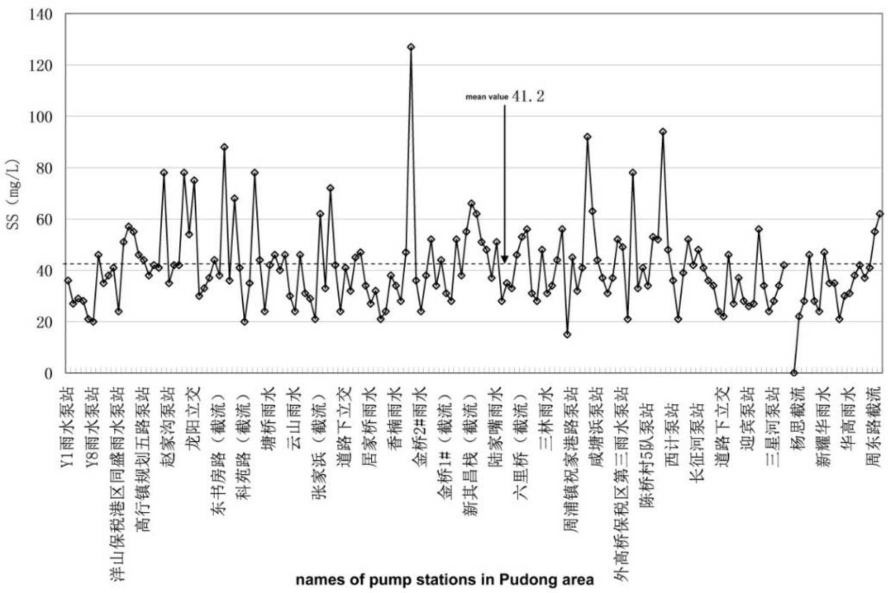


FIGURE 19. Pudong rain pump stations on a not rainy day, SS results (Research Report, 2013-2014)

Figure 19 represents SS results of water on a not rainy day in different pump stations. The average value is 41.2 mg/L, while the maximum value reaches 130 mg/L and the minimum value is around 0 mg/L. The most concentrated part belongs to the interval from 20-80 mg/L.

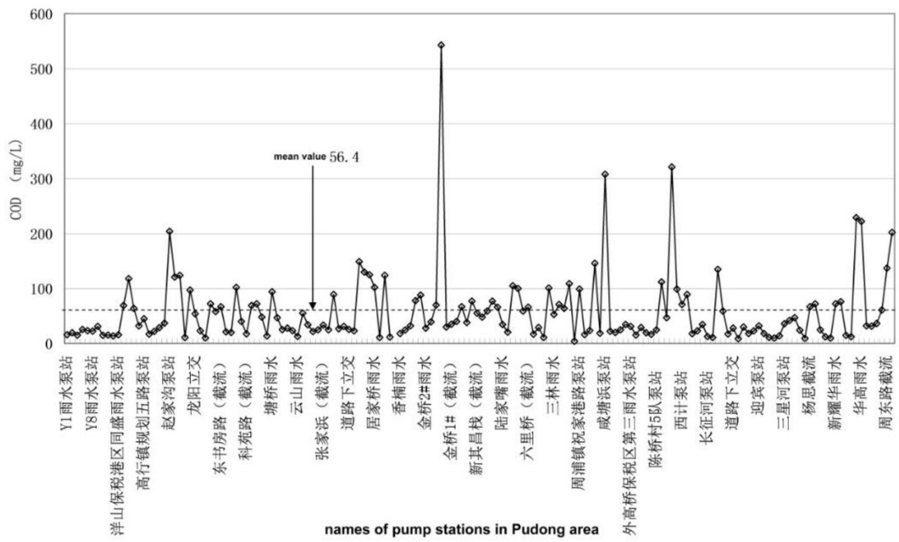


FIGURE 20. Pudong rain pump stations on a not rainy day, COD results (Research Report, 2013-2014)

Figure 20 represents COD results of water on a not rainy day in different pump stations. The average value is 56.4 mg/L, while the maximum value reaches 550 mg/L and the minimum value is around 0 mg/L. The most concentrated part belongs to the interval from 20-100 mg/L.

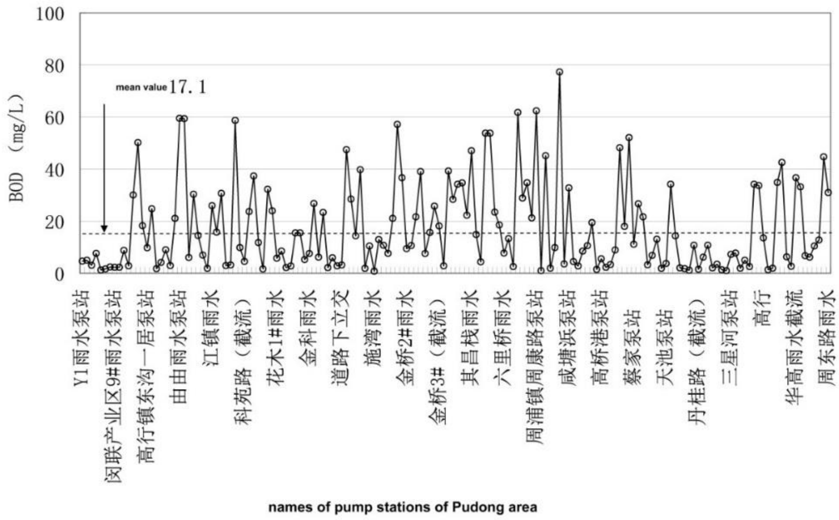


FIGURE 21. Pudong rain pump stations on a not rainy day, BOD results (Research Report, 2013-2014)

Figure 21 represents BOD results of water on a not rainy day in different pump stations. The average value is 17.1 mg/L, while the maximum value reaches 78 mg/L and the minimum value is around 0 mg/L. The most concentrated part belongs to the interval from 0-40 mg/L.

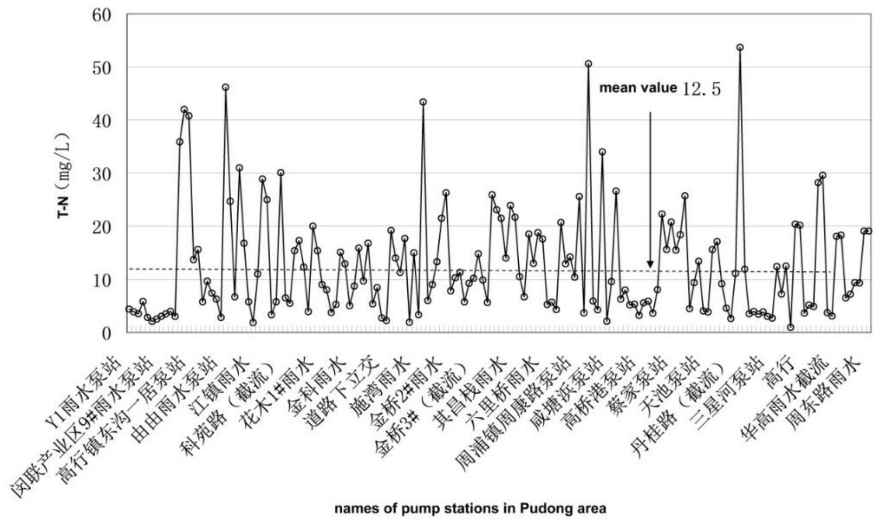


FIGURE 22. Pudong rain pump stations on a not rainy day, T-N results (Research Report, 2013-2014)

Figure 22 represents T-N results of water on a not rainy day in different pump stations. The average value is 12.5 mg/L, while the maximum value reaches 55 mg/L and the minimum value is around 0 mg/L. The most concentrated part belongs to the interval from 5-20 mg/L.

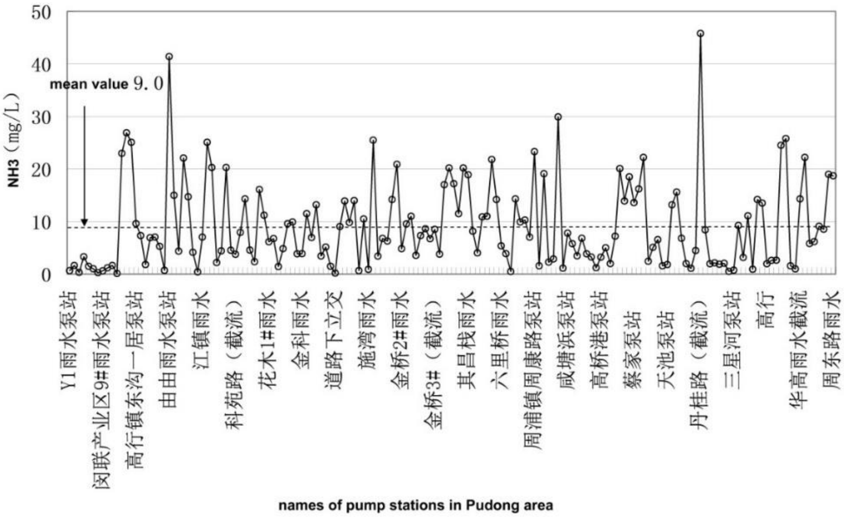


FIGURE 23. Pudong rain pump stations on a not rainy day, NH_3 results (Research Report, 2013-2014)

Figure 23 represents NH_3 results of water on a not rainy day in different pump stations. The average value is 9.0 mg/L, while the maximum value reaches 46 mg/L and the minimum value is around 0 mg/L. The most concentrated part belongs to the interval from 0-15 mg/L.

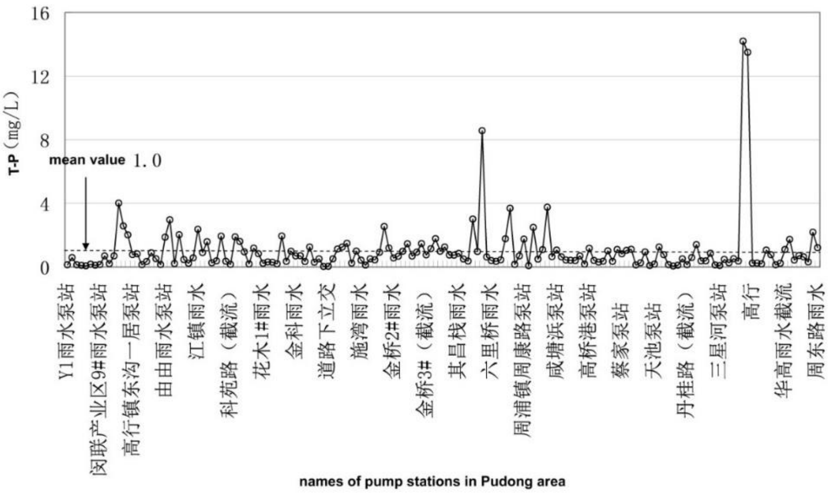


FIGURE 24. Pudong rain pump stations on a not rainy day, T-P results (Research Report, 2013-2014)

Figure 24 represents T-P results of water on a not rainy day in different pump stations. The average value is 1.0 mg/L, while the maximum value reaches 14 mg/L and the minimum value is around 0 mg/L. The most concentrated part belongs to the interval from 0-2 mg/L.

2.3.4.2 COD results of Gong Yuan Shan Cun Pump Station, Lujiabang River

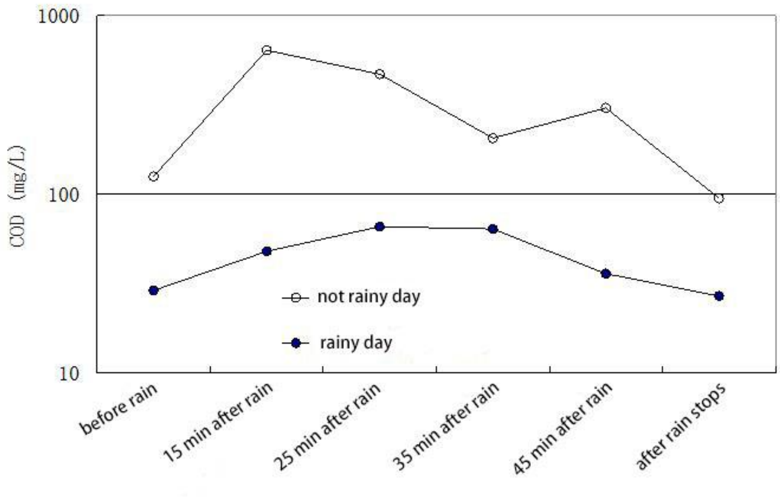


Figure 25. Comparison of COD results in Gong Yuan Shan Cun Pump Station on rainy and not rainy day (Research Report, 2013-2014)

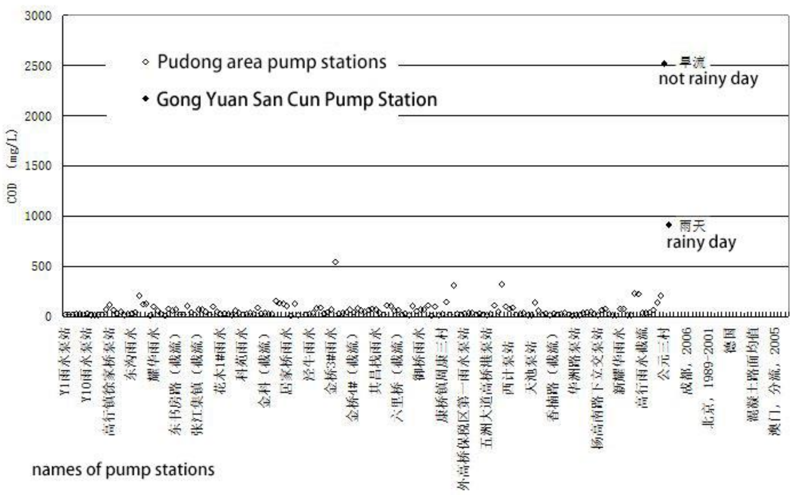


Figure 26. Comparison of COD results between Gong Yuan Shan Cun Pump Station and pump stations in Pudong Area on rainy and not rainy day. (Research Report, 2013-2014)

2.3.4.3 Discharge of water from the pump station (on a not rainy day)

Figures 28-32 represent the comparison between rain pump station on a not rainy day and runoff water. The runoff water is considered as the water from the streets on a not rainy day. All the samples were taken from the rivers that run in Pudong area.

From most of these figures it can be noticed that water on a not rainy day in pump stations in less polluted than the runoff water. This happens as the water cannot be totally discharged from the sink. Thus, some amount of water is still stored in the sink. In not rainy day most of the chemical components settle down in the water forming sludge. However, the samples are taken from the top of the water stored in the sink, so it may cause difference in values between runoff water and the water sample taken from the pump station on a not rainy day.

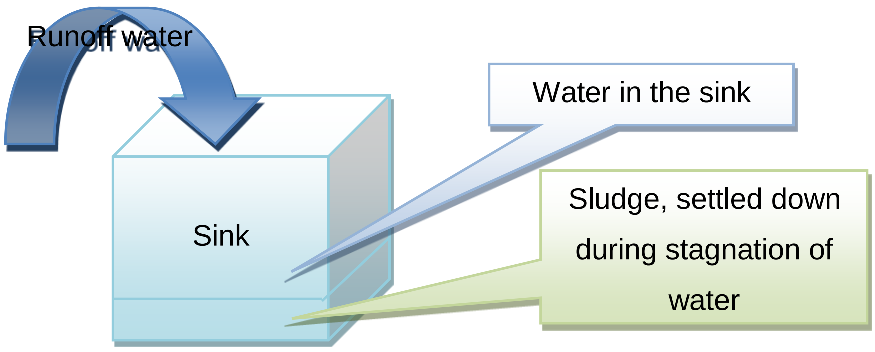


FIGURE 27. Runoff water division

Figure 27 represents the runoff water after coming to the sink. After a period of time water forms sludge on the bottom of the sink, which consists of contaminants. That means that the water on the top of the sink gets cleaner than before, when it just came into the sink.

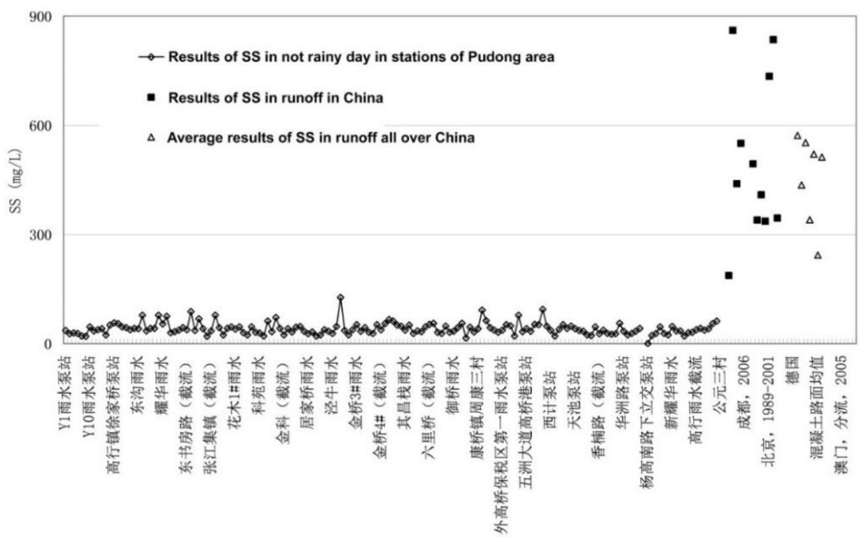


FIGURE 28. Comparison of SS concentration (Research Report, 2013-2014)

From Figure 28 we can see that the results of SS values in water runoff all over China and average results are higher compared to the results of SS values in the stations of Pudong area.

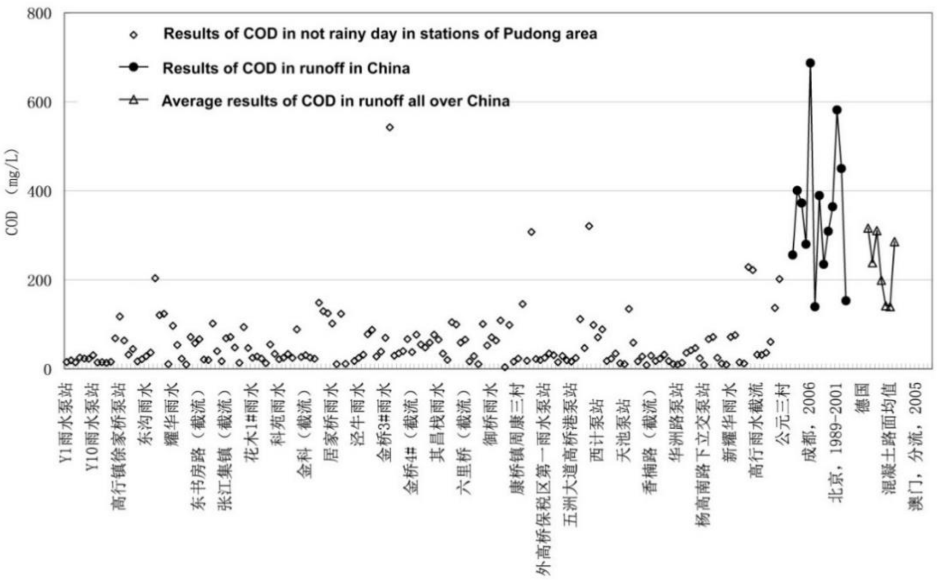


FIGURE 29. Comparison of COD concentration (Research Report, 2013-2014)

From Figure 29 we can see that the results of COD values in water runoff all over China and average results are higher compared to the results of COD values in the stations of Pudong area.

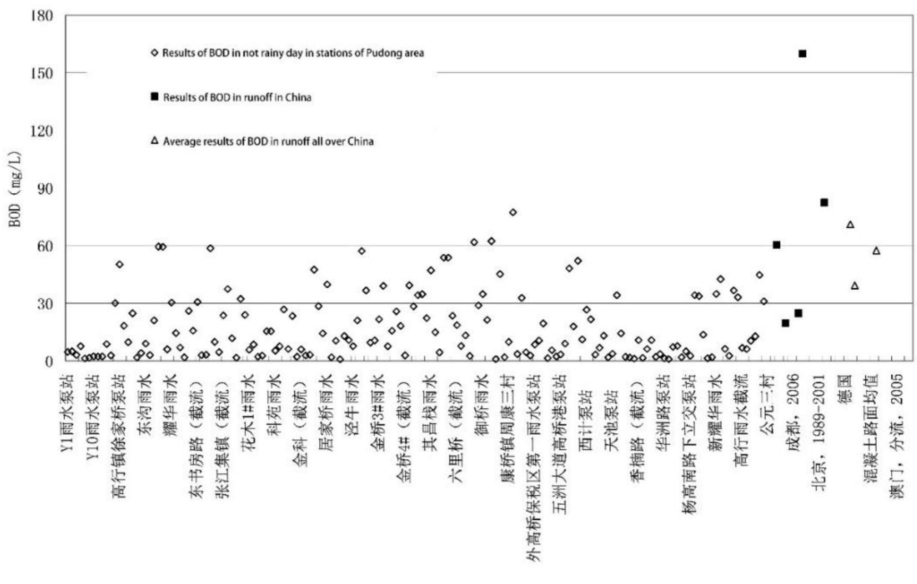


FIGURE 30. Comparison of BOD concentration (Research Report, 2013-2014)

From Figure 30 we can see that the results of Biochemical Oxygen Demand (BOD) values in water runoff all over China and average results are close to the results of BOD values in the stations of Pudong area.

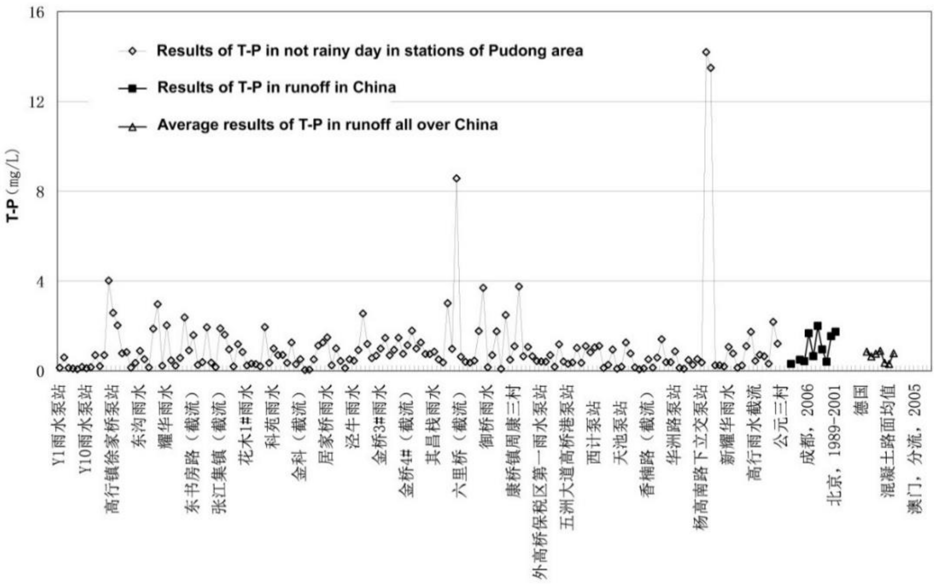


FIGURE 31. Comparison of T-P concentration (Research Report, 2013-2014)

From Figure 31 we can see that the results of T-P values in water runoff all over China and average results are lower compared to the results of T-P values in the stations of Pudong area.

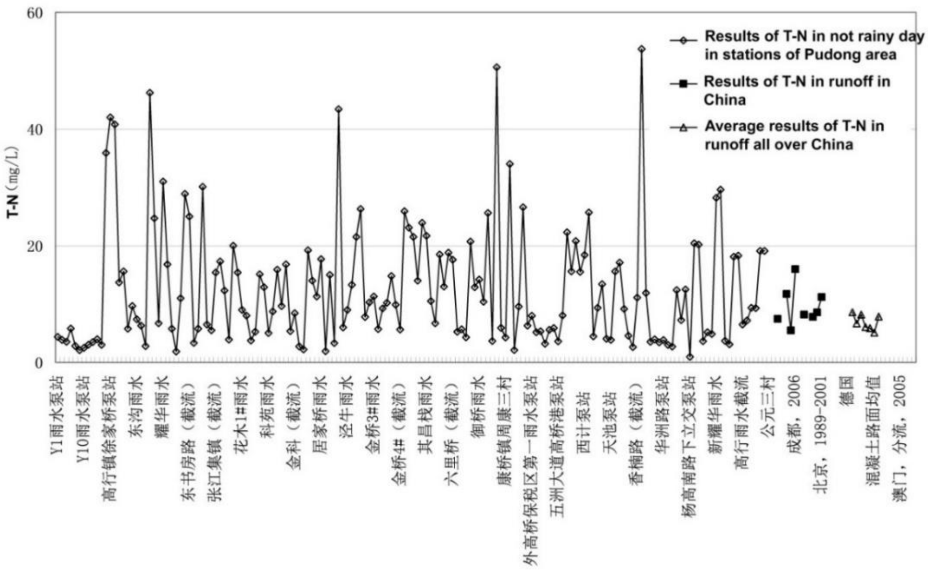


FIGURE 32. Comparison of T-N concentration (Research Report, 2013-2014)

From Figure 32 we can see that the results of T-N values in water runoff all over China and average results are similar to the results of T-N values in the stations of Pudong area.

2.3.4.4 Comparison between pump station and runoff

Below the values of different chemical components between water of pump stations of Pudong area and runoff water overseas are compared.

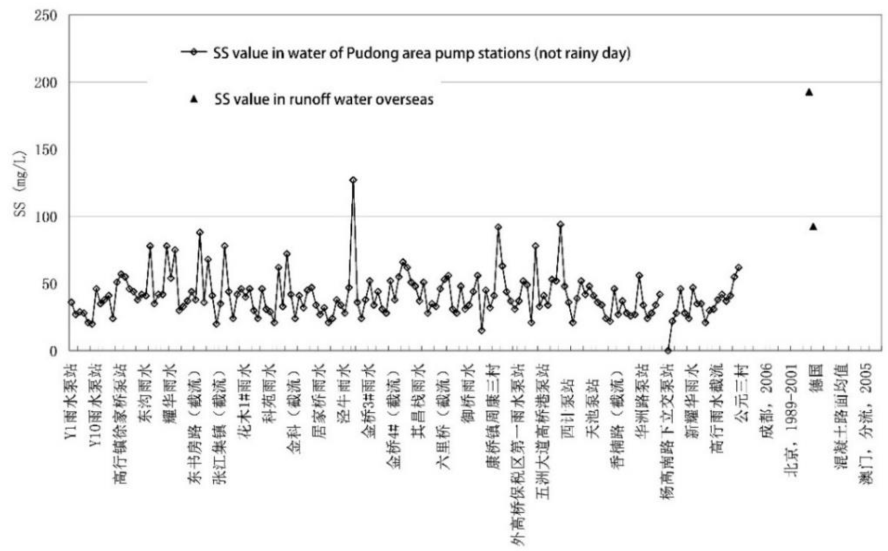


FIGURE 33. Comparison of SS concentration (Research Report, 2013-2014)

From Figure 33 we can see that the results of SS values that were taken from rain pump stations in Pudong area on a not rainy day are lower compared to the results of SS values in water runoff overseas. However, it also shows that in overseas areas the water is highly polluted.

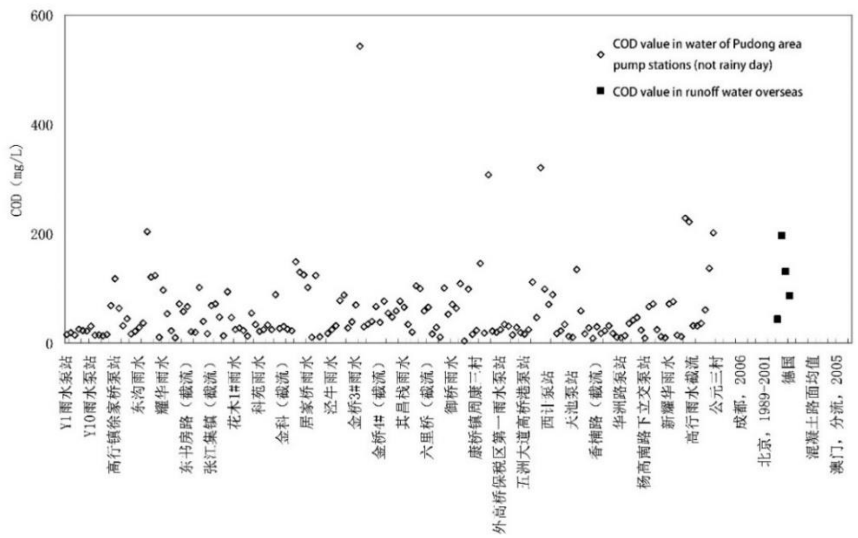


FIGURE 34. Comparison of COD concentration (Research Report, 2013-2014)

From Figure 34 we can see that the results of COD values that were taken from rain pump stations in Pudong area on a not rainy day are close to the results of COD values in water runoff overseas. This figure also demonstrates that COD value on the roads is lower.

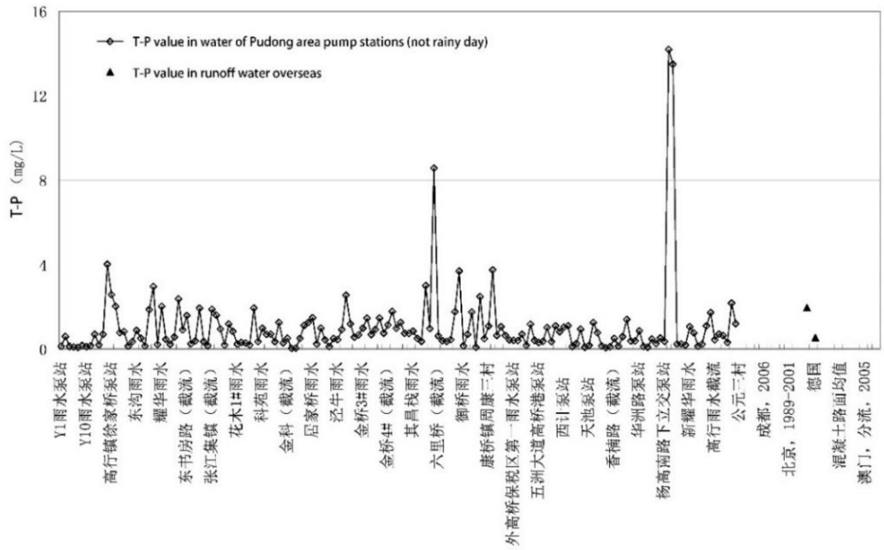


FIGURE 35. Comparison of T-P concentration (Research Report, 2013-2014)

From Figure 35 we can see that the results of T-P values that were taken from rain pump stations in Pudong area on a not rainy day are the same compared to the results of T-P values in water runoff overseas.

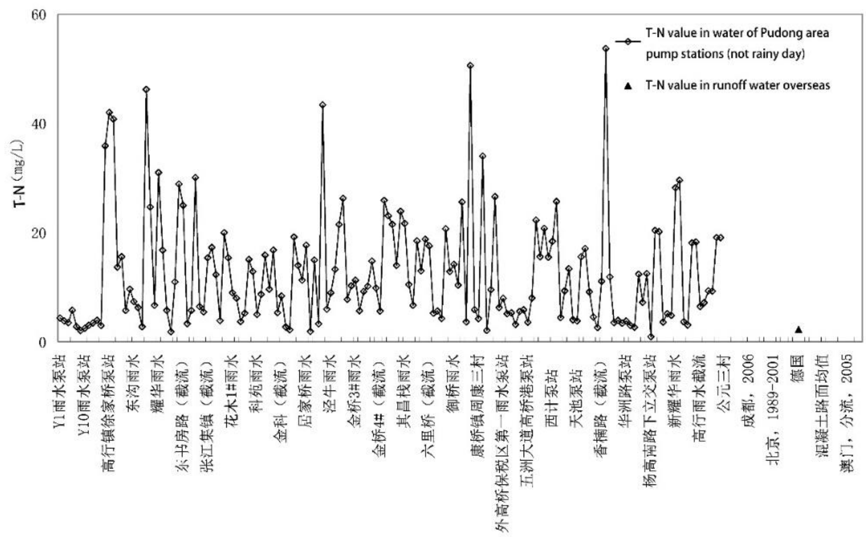


FIGURE 36. Comparison of T-N concentration (Research Report, 2013-2014)

From Figure 36 we can see that the results of T-N values that were taken from rain pump stations in Pudong area on a not rainy day are lower compared to the results of

T-N values in water runoff overseas, which means that the water runoff overseas contains less T-N than there is in the pump station.

2.3.4.5 Comparison between rain pump station and sewage

This chapter compares the values of COD, BOD, T-P, T-N and SS in rain pump stations and sewage in different cities in China (Table 1).

TABLE 1. Comparison between pump station and sewage

Pumping domestic sewage outfall (mg/L)	**COD**	**BOD**	**T-P**	**T-N**	**SS**
Beijing (confluence), 2004	190		2.36	26.4	350
Wuhan (confluence), 2003	299.2		0.88	12.26	601.1
Kunming (confluence), 2007	201.03	86.11	2.51	27.37	228.7
Zhuhai (distributary), 2000	77.51	7.16	0.48	4.96	569.34
Average of distributary	137.86	7.16	0.87	5.91	403.85
Average of confluence	230. 08	86.11	1.92	22.01	393.27
Average value in pump station all over China (mg/L)					
Average value in city	193.19	46.64	1.5	15.57	397.5
Average value in Pudong pump stations (not rainy day)	56.4	17.1	1	12.5	41.2

*It is considered that as lower is the value as better it is for the water quality

When following Table 1 it can be noticed that:

- COD value in pump station is lower than in sewage
- BOD value in pump station is lower than in sewage
- T-P value in pump station is close to its value in sewage
- T-N value in pump station is close to its value in sewage
- SS value in pump station is lower than in sewage

3 ENVIRONMENTAL MANAGEMENT

This part of thesis is based on the course study “Environmental Planning and Management”, which basically focuses on managing the manufacturing process not harming the environment. The course was taken in Shanghai Second Polytechnic University, Shanghai, China.

It is clarified that the scale of the environmental pollution and its degradation is mostly generated by industrial waste. That means while creating different products and services striving at satisfying customer needs, many companies do not take a sufficient control about the environment, polluting the atmosphere with hazardous gases and chemical elements. Thus, the most important point in achieving sustainable development is the ability to manage human impact on the environment. Strategic planning and environmental management play an important role both from managerial and technical perspectives for achieving sustainable development.

Successful companies nowadays are not only evaluated by profit but also by the ability to protect the natural environment. It should be recognized that green products not always cost more but give the company an ability to become more competitive, modern and perspective in a global market.

3.1.1 Strategic Environmental Management

There are some approaches on how to incorporate environmental management in order to achieve competitiveness in the growing environmental market:

- ✓ To expand innovation and productivity
- ✓ To create better environmental performance
- ✓ To improve bottom line
- ✓ To ensure prospected handling of changeable environmental controversy
- ✓ To enhance the trust
- ✓ To involve more employees into community relations

The final result for profit making organizations will be to improve the bottom line by developing more efficient and innovative system with adopting a vision for the future.
The idea of Environmental management strategy is in eliminating waste, less dependence on energy and material, and more efficient use of technologies. Clearly, it demands new environmental standards.

3.1.2 Environmental Planning Framework

The chart below (Table 2) represents the environmental planning process, which describes that main aspects in Quality Management are Plan-Do-Check-Act. This strategic cycle was popularized by Dr. Edward W. Deming. On this chart it is shown that all these phases go one by one, but every following process has a back connection with the previous one. This means that during this process some small changes might be implemented and all of them are connected with each other.

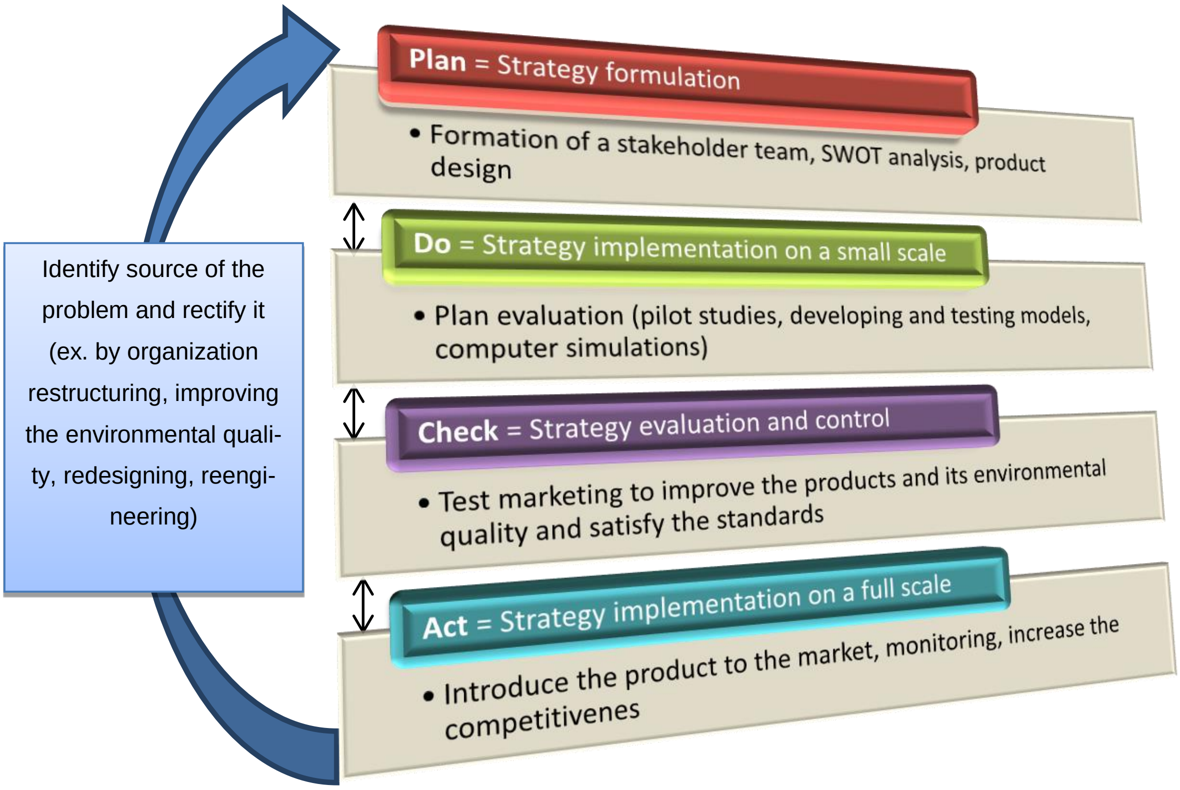


TABLE 2. Environmental Planning Framework (Christian N. Madu, 2007)

There are several strategies that were developed to achieve sustainable manufacturing. They are represented below (Table 3):

TABLE 3. Strategies of Sustainable Manufacturing (Christian N. Madu, 2007)

Inverse manufacturing
- Redesign the components to maximum of their potential (minimize environmental costs)

Recycling
- Reuse of old components

Re-manufacturing
- Rebuild a product to specifications of original manufactured products

Reverse logistics
- Moving goods from their typical final destination (for capturing value or proper disposal). Focus on:
  - Recycling
  - Evaluation of equipment design and product selection
  - Environmental impact assessment of all manufacturing processes
  - Logistics analysis for the collection of products at the end of their lives
  - Safe disposal of hazardous wastes and unusable components
  - Communication with external organizations

Eco-labeling
- Reduce environmental impact associated with consumption of goods and services

ISO 14000 - international standards on Environmental management
- Environmental management systems (ISO 14000, ISO 14001, ISO 14004)
- Environmental auditing (ISO 14010, ISO 14011, ISO 14012)
- Environmental performance evaluations (ISO 14031)
- Environmental labeling (ISO 14020, ISO 14021, ISO 14022, ISO14023, ISO 14024)
- Life cycle assessment (ISO 14040, ISO 14041, ISO 14042, ISO 14043)
- Environmental aspects in product standards (ISO 14060)
- Terms and definitions (ISO 14050)

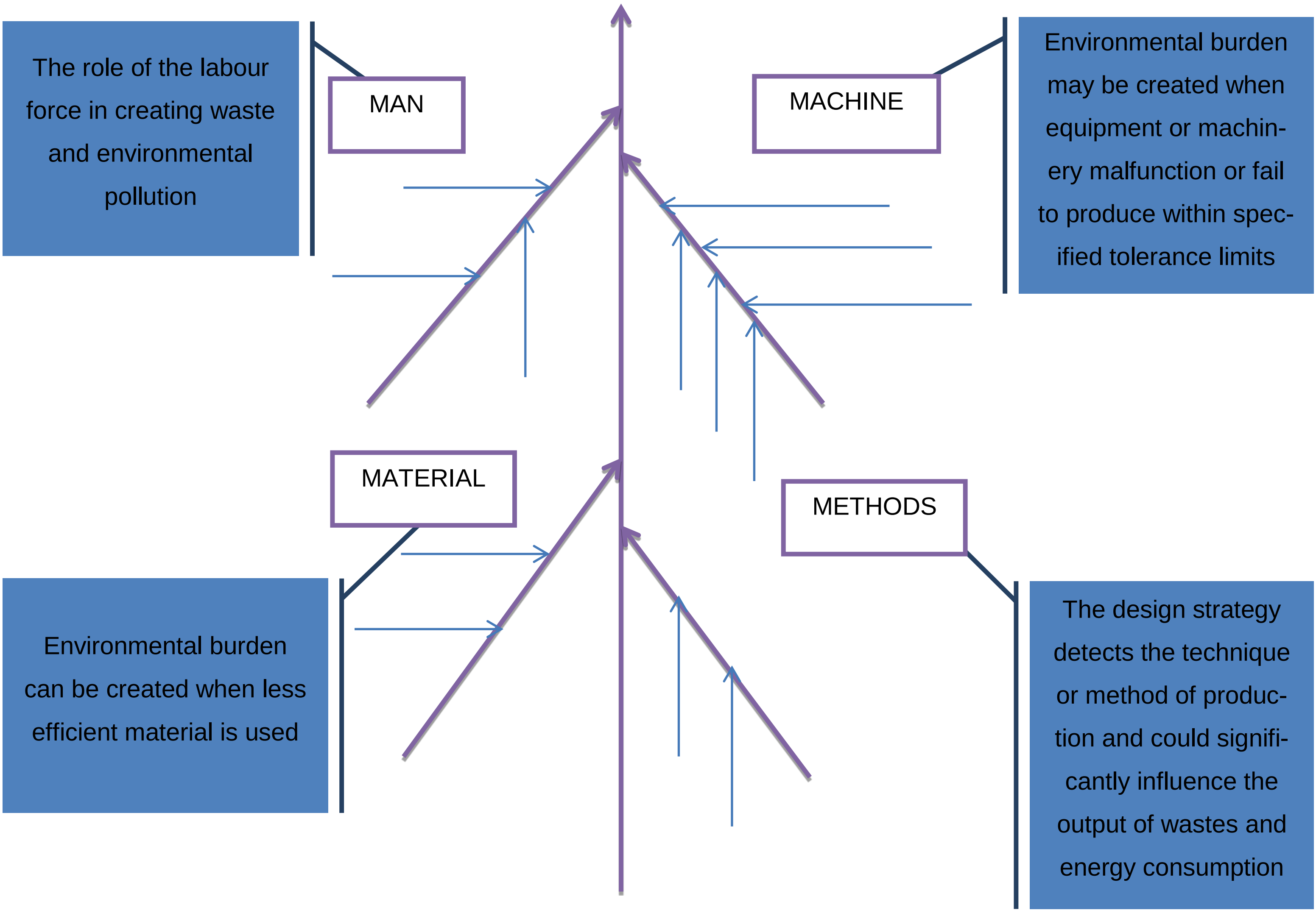
Life cycle assessment
- Inverntory analysis (identification of resource use and environmental discharges to air, water and land)
- Impact analysis (technical assessments of environmental risks and degradation)
- Improvement of environmental performance

Design for the environment
- Design for recyclability
- Design for remanufacture
- Design for disposability

3.1.3 Understanding Environmental Problems

Below is represented Fishbone diagram which is based on the idea that every environmental problem can be managed through analysing of 4*m*s: man, machine, methods and material. (Table 4) For every certain case this diagram the “bones” of the diagram might be changed depending on the issue.

TABLE 4. Fishbone diagram (4*m)* (Christian N. Madu, 2007)



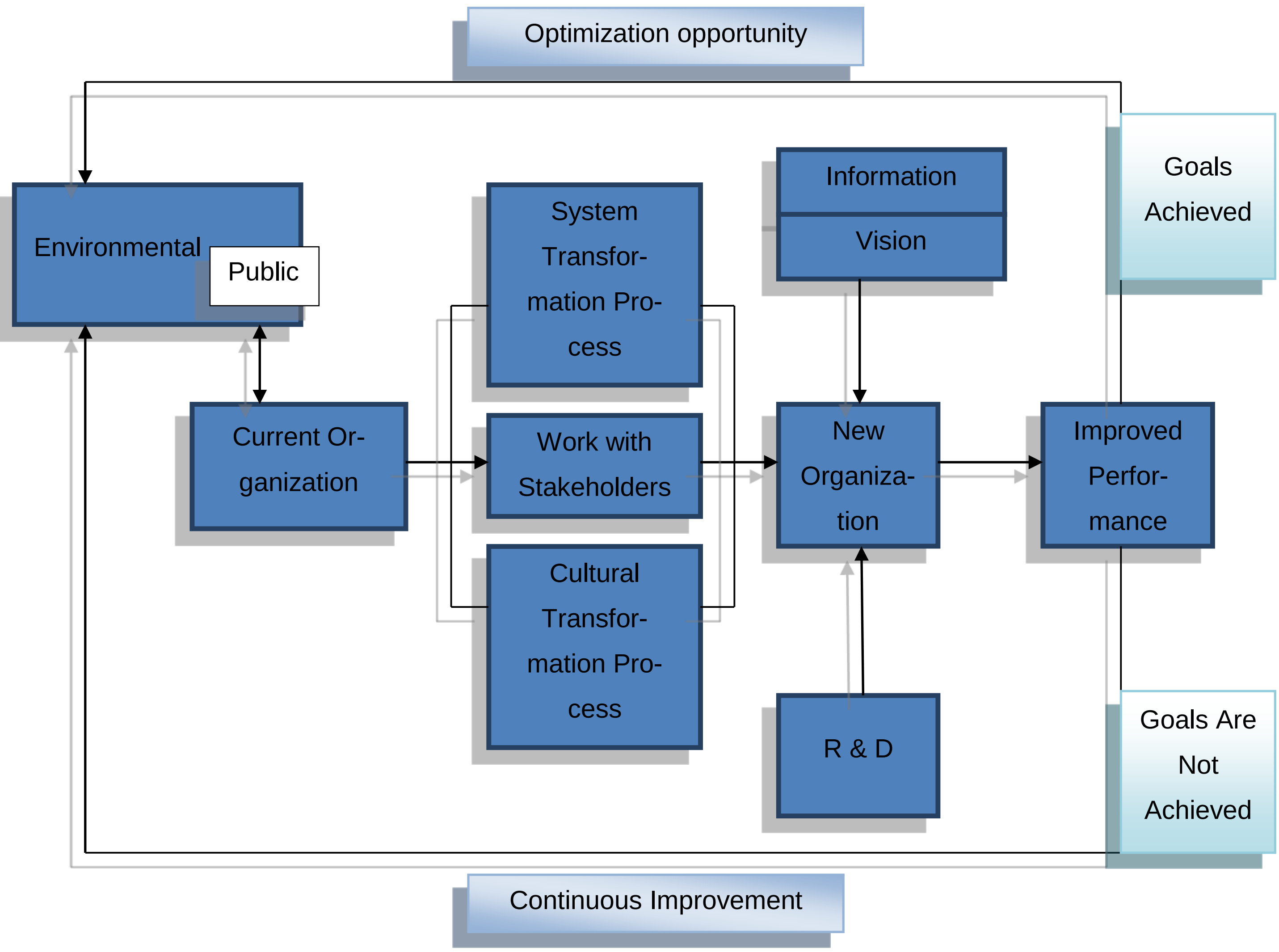
When follow this diagram it is obvious that an efficient planning process must include the consideration of man, materials, machine, and methods. Thus, the environmental impact of each product or service should be evaluated on the basis of those 4*m*s as it helps to better project the environmental burdens of every particular organization.

3.1.4 Organizational Cultures and Environmental Planning

For an effective planning organizational culture should be changed. This will require top managers to take active participation in total system overhaul. Build totally new culture will require attitude and value changes from employees as well. Top management must commit both time and resources in terms of factory modernization by adopting new and more environmentally friendly processes, education and training of employees to teach them the importance of environmental-quality standards and their role in meeting the environmental goals of the company, and better relationship with suppliers and vendors to ensure that they follow cooperative environmental guidelines and polices. This training will help to achieve sustainable manufacturing practices and realize the importance of environmental quality planning. After that senior management begins to analyse the buying patterns of consumers as they relate to the environment. He also needs to encourage process and organizational transformation and redesign.

Table 5 represents customers' needs and the requirement of keeping the balance between environmental protection and product satisfaction. An ideal product is high-quality and environmentally friendly at the same time. System transformation process that is shown on the chart deals with transforming outputs and inputs process.

TABLE 5. Transformation to a green organization (Christian N. Madu, 2007)



Stakeholder team is highly important while developing the planning framework. This team would be made up of active participants with multidisciplinary background and different worldviews which can provide valuable information on its wants and needs. The chart below shows the corporate environmental strategies that could be undertaken in order to achieve corporate missions (Table 6):

TABLE 6. Corporate Environmental Strategies (Christian N. Madu, 2007)

Top management commitment
- ensuring that corporate envirronmental strategies are successful

Organizational vision and mission
- undertanding of SWOT analysis

Change management
- re-engineering and re-structuring

Designing for the new environment
- according to recycling strategy

Competitive benchmarking
- learning and strategy adjusting from world-class organizations

Environmental cost
- developing comprehensive cost assessment methology

Corporate image and social responsibility
- ensuring environmental quality

Strategic information management system
- sharing of information

3.1.5 Environmental Risk Assessments and Management

It is important to quantify the risks associated with hazards that result from environmental burden. Potential risks are not always easy to evaluate, however, by good planning and management strategy those risks can be minimized. Such measures include the following:

- ✓ Designing for the environment
- ✓ Recycling polices
- ✓ Educated consumer
- ✓ Legislations and laws
- ✓ Adopting ISO standards

Table 7 represents the elements of risk assessment. According to the figure, framework starts with problem formulation, which is influenced by economic, political, social and legal factors. The potential hazards from an activity are identified and released by different environmental media – land, air and water. Risk evaluation is also performed to determine what risks are affected, their creation and control. A quantitative measure of risk is then conducted by combining exposure assessment and consequence analysis (Table 7).

TABLE 7. The Elements of Risk Assessments (Christian N. Madu, 2007)

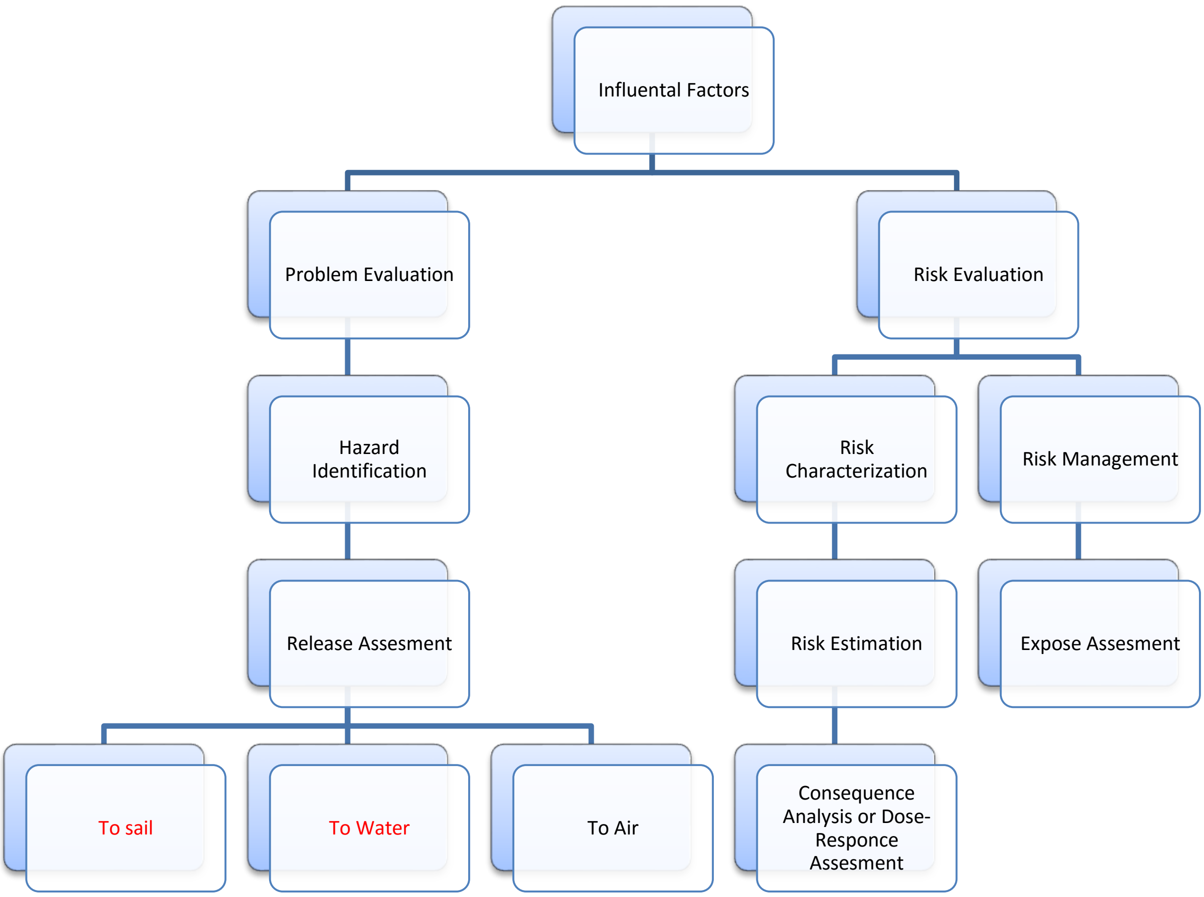
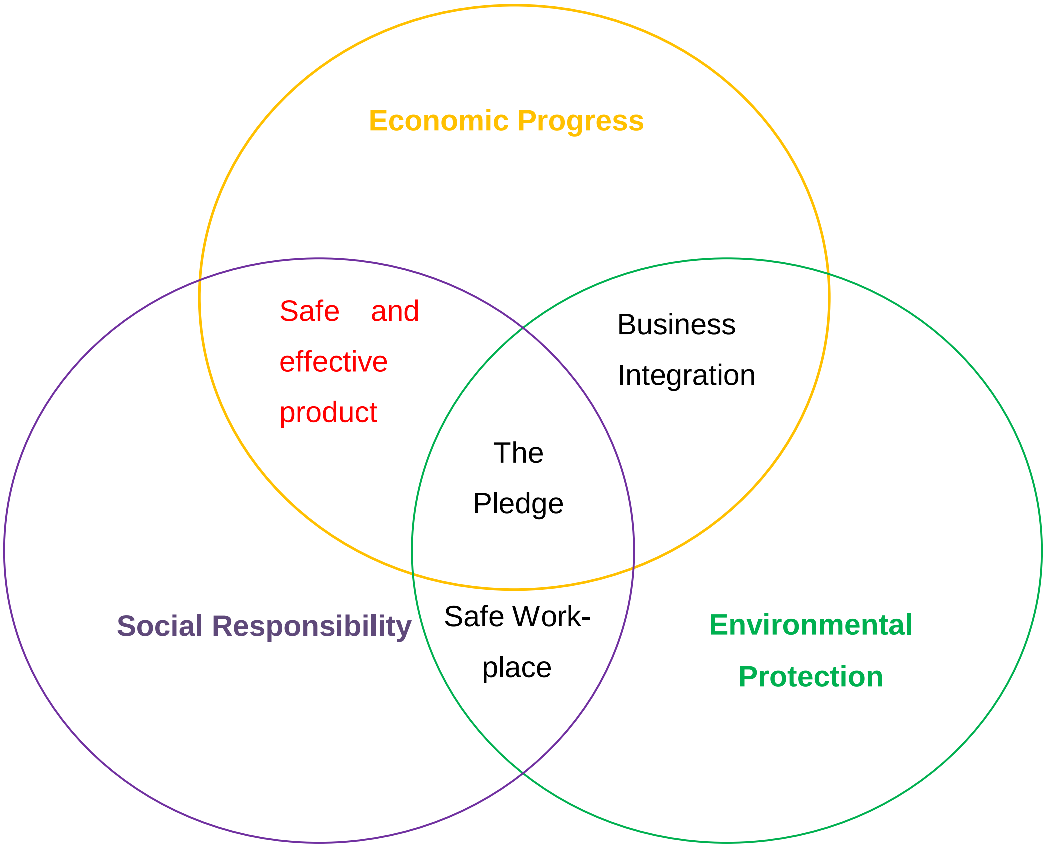


Table 8 is based on the estimation of net value by looking at the integration of economic, social and environmental impact on society. It intends to increase stakeholders' wealth and value to the community while reducing environmental burden and hazard. Employees play major role and suppliers are active participants as well. Environmental impacts on all the environmental media (land, water, air) are assessed.

TABLE 8. Integrating Economic, Social and Environmental Issues (Christian N. Madu, 2007)



*Social Responsibility***,** which can also be referred to *technical issue*, (Table 8) stands for making the customer enjoying the finished products and making the manufacturing process safer, newer and greener. Nowadays companies are concerned about the way raw materials are collected and processed as they want to reduce their footprint on the environment, which will lead to improvement of life quality. Sustainable products are produced in a closed-loop system, which means that recycled raw materials are used and any existing waste is not toxic and can be safely thrown away.

Economic Progress (Table 8) considers not only price, but also current and future social and environmental costs and benefits. Sustainable products are tested to meet performance standards of industry. While they started out relatively more expensive than ordinary products when first introduced, they now meet market criteria in cost. Some manufacturers have also found their production costs to be lower than of products manufactured through traditional methods.

Environmental Protection (Table 8) focuses global attention on the environment has revolutionized the way products are made and used. Manufacturers are using methods that care for the environment and people. Production techniques have evolved to use energy, technologies and materials that make the world a cleaner, greener and safer place.

4 LEGISLATION FOR SURFACE WATERS

Nowadays, the issue of water control methods in manufacturing process is very much considered in Russia. Russian government regulates activities of enterprises and forbids discharging of untreated water to rivers and water bodies until it reaches the established standards. This part represents Chinese and Russian legislation for water quality to give the object lesson of river quality regulations of these two countries.

4.1 Russian standards

Hydro-chemical Institute has developed Guidelines for the evaluation of the pollution status of surface water. To analyse water pollution, specific combinatorial index of water pollution (UKIZV) is used. UKIZV value can range from 1 to 11 (and above), the higher the value, the worse the quality of the water. The final evaluation of surface waters of Saint-Petersburg is given in the Table 11.

Classification of the degree of water pollution - a conditional division of the entire composition range and the natural properties of water into different intervals with a gradual transition from "comparatively clean" to "extremely dirty". (Table 9).

TABLE 9. Classification of surface water contamination (Northwest Management of Hydrometeorology and Environment Monitoring, 2012)

Level of water quality	Category	The degree of water pollution
I level	-	comparatively clean
II level	-	slightly polluted
III level	category "A" category "B"	polluted very polluted
IV level	category of "A" and "B" category of "C" and "D"	dirty very dirty
V level	-	extremely dirty

When evaluating fishery ponds as well as water bodies for drinking and community water use, the most stringent (minimum) value of the maximum permissible concentration (MPC) of hazardous substances is used.

Complex water pollution indexes are calculated by the 17 ingredients: DO, BOD_5, COD, phenol, petroleum, $N\text{-}NH_4$, nitrite nitrogen ($N\text{-}NO_2$), total iron (Fe), Cu, Zn,

nickel (Ni), Mn, Cd, Pb, chlorides, sulphates, Sodium Dodecyl Sulphate (SDS). (Table 10)
“In 2012, in St. Petersburg in the cross-sections of the State Observation Network (SON) there were not fixed values qualified as extremely high pollution (EHP). 9 concentration values, qualified as the HP were noted.” (Russian Federal Service for Hydrometeorology and Environmental Monitoring, 2000). (Table 10)

TABLE 10. Cases of High Pollution from State Observation Network of St. Petersburg (Northwest Management of Hydrometeorology and Environment Monitoring, 2012)

Water object	Date of indicators selection	Quality cases, for which HP concentration was recorded
Kamenka River- 0.5 km below the delta Kamenka; motor-road bridge	07.11	NO_3-N - 0.227 mg/dm^3 (11.4 MPC)
	05.12	Mn - 0.366 mg/dm^3 (36.6 MPC)
Karpovka River - 0,025 km above the mouth	07.02	Pb - 0.028 mg/dm^3 (4.7 MPC)
Bypass Canal - 0,025 km above the mouth	17.05	NO_3-N - 0.251 mg/dm^3 (12.6 MPC)
Ohta River – 1) 0.05 km above the mouth	08.08	DO -2.7 mg/dm^3
	04.12	Mn - 0.340 mg/dm^3 (34.0 MPC)
Ohta river – 2) in the alignment of the bridge ave. Shaumyan	14.03	Pb - 0.023 mg/dm^3 (3.8 MPC)
	03.04	Mn - 0.384 mg/dm^3 (38.4 MPC)
	05.07	DO -2.3 mg/dm^3

TABLE 11. Evaluation of the water quality in rivers in St. Petersburg (Northwest Management of Hydrometeorology and Environment Monitoring, 2012)

№ of alignment	Water object	UKIZV (Quality class) characterization of the state of water pollution (CTC)
141	ave. w/n № 840	(3 "B") is very polluted (Fe)
142	Kamenka River	(4 "A") is dirty (N-NO_2, Mn)

161 (1)	Neva River	(3 "A") is polluted
161 (2)	Neva River	(3 "A") is polluted
161 (3)	Neva River	(3 "A") is polluted
161 (4)	Neva River	(3 "A") is polluted
161 (5)	Neva River	(3 "A") is polluted
161 (6)	Big Nevka	(3 "A") is polluted
162	Big Nevka	(3 "A") is polluted
163	Karpovka River	(3 "B") is very polluted (Pb)
164	Black River	(3 "B") is very polluted
165	Small Nevka	(3 "A") is polluted
166	Fontanka River	(2) is slightly polluted
167	Mojka River	(3 "A") is polluted
168	Malaya Neva	(3 "A") is polluted
169	Zhdanovka River	(2) is slightly polluted
172	Izhova River	(3 "B") is very polluted
173	Slavyanka River	(3 "B") is very polluted
174	Obvodnij Canel	(3 "B") is very polluted (N_{NO2})
175 (1)	Ohta River	(4 "A") is dirty (Mn)
175 (2)	Ohta River	(4 "B") is dirty (O_2, Mn, Fe)
175 (3)	Ohta River	(4 "A") is dirty (Fe)

Requirements of Russian authorities for quality control of water levels include
:

- ✓ operational process control with automatic online analysers and continuous automatic monitoring systems;
- ✓ laboratory control;
- ✓ monitoring by an independent organization - the Centre of research and monitoring of water quality;
- ✓ control by “Rospotrebnadzor” (the main government agency for protecting the rights and welfare of consumers in Russia)

4.2 Chinese standards

The newest standard of surface water environment is GB3838-2002. The older standards GB3838-88, GHZB1-1999 are not used anymore.

New water standard classification is based on surface water features and objectives of water environment protection. Thus, according to the level of function it is divided into five categories: (Table 12)

I level - mainly applied to the source of water, national nature reserves;

II level - mainly suitable for centralized surface drinking water source protection areas, rare aquatic habitats, fish and shrimp spawning ground, the larvae feeding grounds, etc.;

III level - mainly suitable for centralized drinking surface water source for protected areas, fish and shrimp, wintering grounds and submerge swim the channel, aquaculture areas and other fishing waters and swimming area;

IV level - mainly applied to general industrial water areas and recreational water area of the body without direct contact;

V level - mainly applicable to agricultural water area and the general landscape water requirements.

TABLE 12. Limitations (mg/L) (Surface Water Quality Standards, 2002)

No.	Classification / standard value / project		Ⅰ level	Ⅱ level	Ⅲ level	Ⅳ level	Ⅴ level
1	Water temperature T (℃)		Environmental temperature changes caused by human activity should be limited to: Weekly average maximum temperature rise ≤1 The maximum weekly average temperature drop ≤2				
2	pH value (dimensionless)		6～9				
3	Dissolved oxygen (DO)	≥	Saturation rate of 90% (or 7.5)	6	5	3	2
4	Permanganate index	≤	2	4	6	10	15
5	COD	≤	15	15	20	30	40
6	BOD (BOD5)	≤	3	3	4	6	10
7	NH3-N	≤	0.15	0.5	1.0	1.5	2.0
8	T-P (with T-P count)	≤	0.02 (Lakes, reservoirs 0.01)	0.1 (Lakes, reservoirs	0.2 (Lakes, reservoirs	0.3 (Lakes, reservoirs	0.4 (Lakes, reservoirs

				0.025)	0.05)	0.1)	0.2)
9	T-N (lakes and reservoirs)	≤	0.2	0.5	1.0	1.5	2.0
10	Copper (Cu)	≤	0.01	1.0	1.0	1.0	1.0
11	Zinc (Zn)	≤	0.05	1.0	1.0	2.0	2.0
12	Fluoride (F)	≤	1.0	1.0	1.0	1.5	1.5
13	Selenium (Se)	≤	0.01	0.01	0.01	0.02	0.02
14	Arsenic (As)	≤	0.05	0.05	0.05	0.1	0.1
15	Mercury (Hg)	≤	0.00005	0.00005	0.0001	0.001	0.001
16	Cadmium (Cd)	≤	0.001	0.005	0.005	0.005	0.01
17	Chromium (hexa-valent) (Cr)	≤	0.01	0.05	0.05	0.05	0.1
18	Lead (Pb)	≤	0.01	0.01	0.05	0.05	0.1
19	Cyanide(Cn-)	≤	0.005	0.05	0.02	0.2	0.2
20	Volatile phe-nol(C_7H_8O)	≤	0.002	0.002	0.005	0.01	0.1
21	Petroleum	≤	0.05	0.05	0.05	0.5	1.0
22	Anionic surfac-tants	≤	0.2	0.2	0.2	0.3	0.3
23	Sulphide(S^{2-})	≤	0.05	0.1	0.2	0.5	1.0
24	Faecal coliform (a/L)	≤	200	2000	10000	20000	40000

Table 13 represents standard basic project analysis for the surface water environment quality, which was described in Table 12.

TABLE 13. Basic Project Analysis (Surface Water Quality Standards, 2002)

No.	**Basic items**	**Analysing method**	**Detection limit mg/L**	**Source method**
1	T (℃)	Thermometer method		GB 13195－91
2	pH	Glass electrode method		GB 6920－86
3	DO	Lodimetric method	0.2	GB 7489－89
		Electrochemical probe method		GB 11913－89

4	Permanganate index		0.5	GB 11892—89
5	COD	Dichromate method	5	CB 11914—89
6	BOD	Dilution and seeding method	2	GB 7488—87
7	NH_3	Nessler's reagent colorimetric	0.05	GB7479—87
		Salicylic acid spectrophotome-try	0.01	GB7481—87
8	T-P	Molybdate spectrophotometry	0.01	GB 11893—89
9	T-N	Alkaline potassium pyrosul-phate digestion - UV spectro-photometric method	0.05	GB 11894-89
10	Cu	2,9-dimethyl-1,10-phenanthroline spectropho-tometry	0.06	GB 7473—87
		Diethyl dithiocarbamate spec-trophotometry	0.010	GB 7474—87
		Atomic absorption spectropho-tometry	0.001	GB7475-87
11	Zn	Atomic absorption spectropho-tometry	0.05	GB 7475—87
12	F	Fluor reagent spectropho-tometry	0.05	GB 7483—87
		Ion Selective Electrode	0.05	GB 7484—87
		Ion Chromatography	0.02	HJ/T84-2001
13	Se	2,3-diaminonaphthalene fluo-rescence	0.00025	GB 11902—89
		Graphite furnace atomic ab-sorption spectrophotometry	0.003	GB/T15505-1995
14	As	Diethyl dithiocarbamate spec-trophotometry silver	0.007	GB 7485—87
		Cold Atomic Fluorescence Spectrometry	0.00006	GB 13195—91
15	Hg	Cold atomic absorption spec-trophotometry	0.00005	GB 7468—87

		Cold Atomic Fluorescence Spectrometry	0.00005	GB 13195—91
16	Cd	Atomic absorption spectrophotometry (chelate extraction)	0.001	GB 7475—87
17	Cr (hexavalent)	Biphenyl hydrazine spectrophotometry	0.004	GB 7467—87
18	Pb	Atomic absorption spectrophotometry chelate extraction	0.01	GB 7475—87
19	T-CN-	Isonicotinic acid - pyrazolone colorimetric	0.004	GB 7487—87
		Pyridine - barbituric acid colorimetric	0.002	GB 7487—87
20	C_7H_8O	After distillation, 4-amino-antipyrine spectrophotometric method	0.002	GB 7490—87
21	Petroleum	Infrared spectrophotometry	0.01	GB/T 16488—1996
22	Anionic surfactants	Methylene blue spectrophotometric	0.05	GB 7494—87
23	S^{2-}	Methylene blue spectrophotometric method	0.005	GB/T 16489—1996
		Direct development of the spectrophotometry	0.004	GB/T 17133—1997
24	Faecal coliforms	Multi-tube fermentation, membrane filter method		GB 13195—91

5 COMPARISON STUDY

This part of thesis is a comparison study of water quality of urban road runoff pollutants between China, Russia and other European and Asian countries.

5.1 Urban main road runoff pollutants in China

The concentration of road runoff depends on precipitation rainfall capacity, monitoring level of road pollution and duration of rainfall. When the cumulative precipitation rainfall capacity is less than 4 mm, concentration of road runoff will not be much influenced during a period of time. When the accumulative precipitation rainfall capacity is less than 13 mm, the concentration of pollutants has a great increase, exceeding the average from several times to a few dozens. However, rainfall duration and concentration of pollutants in storm water samples can be used to show the mean value (Table 14).

TABLE 14. The mean value of urban main road runoff pollutants (Research Report, 2013-2014)

National urban road runoff (mg/L)	COD	BOD_5	T-P	T-N	SS
Shanghai，2001	256	60.33	0.31	7.45	187
Shanghai，2004	400.98		0.71		860.71
Guangzhou，2005-2006	373	19.5	0.49	11.71	439
Wuhan	280		0.42	5.47	550
Chengdu，2006	687.18		1.67	15.99	1534
Chongqing，2000	139.58	24.81	0.65		
Kunming，2007	389.66	159.81	2	8.18	493.56
Nanchang，2007-2008	234.75		0.95		339.25
Suzhou，2004-2005	309.33		0.4	7.8	408.67
Zhenjiang，2006	364.53		1.54	8.56	335.95
Beijing，1989-2001	582		1.74	11.2	734
Xian，1998-1999	450.23	82.4			835.36
Handan，2005	153.26				344.9
Southern China	316.27	71.11	0.85	8.59	572.08
Northern China	238.67	39.29	0.64	6.65	436.01
Extra-large cities	310.94		0.76	8.17	552.36
Middle sized cities	199.13		0.89	6.04	340.03
All over average value	141.87		0.36	5.85	520.76

5.2 Waste water treatment in Russia

Nowadays in Saint-Petersburg 98,5% of all the wastewater is under the cleaning process by following the recommendations of Helsinki (Finland) Commission for the Protection of Baltic Sea. One of the biggest ecological projects, aimed to stop the discharging of untreated sewage into water bodies of the city, was the construction of the main sewage collector in northern part of the city in October, 2013. This main collector, installed in system of municipal sewage, allows to switch 76 direct discharges of untreated household wastewater with consumption of 334.000 m^3 / day.

In the end of 2013 the city government adopted a scheme of water supply and sanitation of Saint-Petersburg for the period up to 2015. In 2015 the Scheme actualization was completed (Table 15). According to the Scheme by year 2020 the discharge of untreated household sewage into water bodies of the city will be totally stopped.

TABLE 15. Wastewater treatment (State Unitary Enterprise "Vodokanal of St. Petersburg", 2015)

No.	Name of the substances	The concentration in the total runoff at the outlet of CBS, mg/l	Regulatory requirements *, mg/l
1	Total Nitrogen (T-N)	9,5	Not more than 10
2	Total Phosphorus (T-P)	0,26	Not more than 0,5
3	SS	7,1	Not more than 10
4	BOD	5,8	Not more than 6

* Standards are taken into account with Russian requirements and recommendations of the Helsinki Commission. Nonpoint source loading represents 71% of nitrogen and 44 % of phosphorus loads.

6 ANALYZING RESULTS

According to the data collected from "Shanghai Pudong Hydrology and Water Resource Administration" the following conclusion of water pollution can be made:
In rain water:

- COD value in rain water is lower compared to COD value in river
- NH_3 value in rain water is lower than its value in river after the water scouring the ground
- T-P value in rain water is close to its value in river after the water scouring the ground

In sub-surface underground water:

- COD, N-NH_3, T-N, T-P in sub-source underground water is lower than in river

In storm water runoff:

- The rainwater pump station rain drainage concentration: the concentration of pollutants in river water pollutants is higher than before.
- The confluence of rainwater and sewage pump station: after rain sewage pump is turned on, the concentration of pollutants in river water was significantly higher than the effect of river water pollutant concentration.

Analysing the monitoring results:

- The monitoring results of COD and SS collected from Pudong New Area pump station on a not rainy day are significantly lower than the monitoring results of road runoff all over China;
- The monitoring results of total nitrogen and total phosphorus collected from Pudong New Area pump station on a not rainy day are similar to the monitoring results of road runoff all over China;
- The monitoring results of COD and SS collected from Pudong New Area pump station on not a rainy day are significantly lower than the monitoring results of pump station sewage outfall all over China;
- Monitoring results of T-N and T-P collected from Pudong New Area pump station on a not rainy day are similar to the pump station sewage outfall results all over China;
- The monitoring results of COD and SS collected from Pudong New Area pump station on a not rainy day are significantly lower than storm water runoff on roads outside of China on a rainy day;
- Monitoring results of T-N and T-P collected from Pudong New Area pump station on a not rainy day are similar to rain runoff on roads outside of China on a rainy day.

7 PLANNING MEASURES

Generally, there are two alternatives that could be implemented for water purification of Lujiabang River. These two methods are based on grey and green infrastructures.

7.1 Method 1

The first one, grey infrastructure is a hand-made system essential in every community. It includes sewer and waste water facilities. The idea that could be referred to this kind of infrastructure is *setting up the treatment plant* for purifying the untreated water before entering the river. As it was mentioned before, Gong Yuan Shan Cun pump station of Lujiabang River is a combined sewer pump station, which means that it collects both rain runoff and waste water. Thus, both sewage and rain runoff come into Lujiabang River directly, bringing pollutants straight into the river. Without treatment plant the huge amount of entering contaminated water cannot be controlled. Even though there is natural process of water self-purification in the rivers, due to a sharp increase of waste, it goes very slowly, creating a need to neutralize, treat wastewater and recycle it. So the treatment plant should be built to purify the contaminated water flowing into the river.

Wastewater treatment is a treatment in order to destroy and remove harmful substances. In the liberation of wastewater from pollution, there are raw materials (waste water) and finished products (purified water).

Purifying methods of waste water can be divided into mechanical, chemical, physicochemical and biological. When all of them are used together this method can be called a combined method. The use of a particular method in each case is determined by the nature and degree of contamination hazard of impurities.

7.1.1 Mechanical method

The idea of mechanical method is to remove mechanical impurities from waste water by sedimentation and filtration. Coarse particles, depending on the size, are trapped by grids, sieves, sand traps, and septic tanks, manure traps of different designs; and surface impurities – by oil separators, petro-oil-collector, settlers and others.

7.1.2 Chemical method

Chemical method is based on adding different chemical reagents into waste water. They react with the pollutants and make them to precipitate as insoluble precipitates.

7.1.3 Physicochemical method

While implementing physicochemical method, finely dispersed and dissolved inorganic and organic impurities and destroyed poorly oxidizable substances should be removed from waste water. In most of the physical and chemical methods coagulation, oxidation, adsorption, extraction, etc. are commonly used. Electrolysis finds wide application fields, too. It is the destruction of organic substances in the waste waters and recovery of metals, acids and other inorganic substances. The electrolytic treatment is carried out in special facilities - electrolysis. Contaminated wastewater is also purified by means of ultrasound, ozone, ion exchange resins and high pressure. Chlorination is a well proven treatment method as well.

7.1.4 Biological method

Biological method plays an important role in water treatment and it is based on using patterns of chemical and biological self-purification of rivers. There are several types of biological devices for water treatment: bio-filters, biological ponds and aero-tanks.

7.1.4.1 Bio-filters

In bio-filters waste water is passed through a layer of coarse material coated with a thin bacterial film. This film helps the processes of biological oxidation to flow intensively and it serves as an active principle in bio-filters.

7.1.4.2 Biological ponds

They are artificial ponds which are used for biological treatment of wastewater by organic substances. Their operating principle is based on self-purification of water by organisms living in it.

7.1.4.3 Aero-tanks

Aero-tanks are huge reservoirs made of reinforced concrete, where cleansing begins with a help of an activated sludge of bacteria and microscopic animals. All these creatures are booming in the aeration tanks, aided by organic waste substances water and excess oxygen flowing into the inlet air flow structure. Bacteria are glued into flakes and secrete enzymes mineralizing organic contamination. Sludge with flakes quickly settles, separating from the treated water. Ciliates, flagellates, amoebae, rotifers and other tiny animals, eating bacteria do not stick together in flakes, rejuvenate the bacterial sludge mass.

7.2 Method 2

Another method of solving water pollution problem of Lujiabang River is based on green infrastructure. Green infrastructure is a natural system to manage rainwater by planting trees and making wetlands instead of building new water treatment plants. The suggested method according to the green infrastructure is to provide the possibility for *sewage flowing to municipal waste water treatment plant* for further purificaton and *rain runoff can be pumped into the river* by pretreatment process. This pretreatment process can be implemented according to green infrustructure design.

Instead of expanding the traditional grey infrastructure and building more pipes and tanks for wastewater treatment, it could be suggested to invest into green infrastructure in order to restore nature's ability to capture the water where it falls, and to use it as a resource before it becomes waste.

Green way of water management involves a differentiated approach: from free distribution of rainwater tanks and landing strategically placed rain gardens in parks, on roadsides and on the roofs of houses, to more complex and costly task, such as replacement of urban roads and sidewalks made of concrete with permeable pavement.

8 PROPOSED SCHEME FOR SELECTION

In chapter 7 two ways of water purification for Lujibang River are suggested. Which method to choose is the primary question of this chapter. To answer this question, advantages and disadvantages of both grey and green infrustructures should be considered. (Table 16)

Table 16. Comparison between grey and green infrustructures (World Resources Institute, 2013)

Infrastructures:	**Grey**	**Green**
Safe	**yes**	**yes**
Effective	**not always**	**yes**
Economical	**no**	**not always**
Energy saving	**no**	**yes**
Easy to maintain	**no**	**yes**
Easy to operate	**no**	**yes**
Less specialists needed	**no**	**yes**

According to Table 16 green infrastructure has its advantages, as it can be less cost consuming, energy saving, easier to maintain and operate which requires lower amount of man-power and less specialists. This infrastructure is not harmful for the environment and contributes sustainable development. On the other hand, grey infrastructure requires energy to operate and it is expensive to construct and maintain. Another issue is that grey infrastructure can actually increase the runoff, as this system does not allow the evapotranspiration, which can manage around half of runoff. This infrastructure also contributes to pollution as it does not permit water to be filtered through the layers of soil. Flooding can also be increased because the structure is designed to move all the water to the infrastructure system, which can be overloaded during storming.

Thus, method 1, which is based on green infrastructure, can be suggested for water treatment process in Lujiabang River. This method will allow protecting, restoring and imitating the natural water cycle to reduce the quantity of storm water flowing into the combined sewer system (CSS). By controlling storm water runoff through the processes of infiltration, evapotranspiration, and capture and use (rainwater harvesting), green infrastructure can help to keep storm water out of the CSS.

9 PLANNING AND IMPLEMENTATION

Decentralized control of pollutant sources helps to reduce the flow of nonpoint pollution into the river and it is based on taking measures of contaminants that trapped down in order to avoid dissolution and diffusion of contamination during rain runoff.

There are several control measures for urban green areas surrounding rivers, roads, slope and other different sources of rainfall runoff to be proposed:

9.1 Sunken greenbelts

In order to reduce the surface runoff from beginning, sunken greenbelts can be made. It is needed to make the greenbelts with average height of 10 cm below the surrounding ground. On the surface of greenbelts, some grass or trees can be planted. The natural soil should be changed to high permeability coefficient of permeable material. From the surface to the bottom there should be: topsoil, gravel, permeable subsoil.

Advantages:

- ✓ Increasing soil storage,
- ✓ Setting undulating terrain,
- ✓ Creating low-lying in the vertical plane,
- ✓ Increasing the infiltration capacity of the soil

This green landscape not only reduces the city runoff, but also the purification control measures of rainfall runoff.

9.2 Buffer zones

On the downhill slope on both sides of river, small trees and grass can be planted as a buffer zone. If the slope is wide enough, a plurality of buffer zones can be made. The buffer zones not only protect water quality, but also work as erosion control and can effectively filter, absorbing sediment and chemical pollution. (Figure 37)

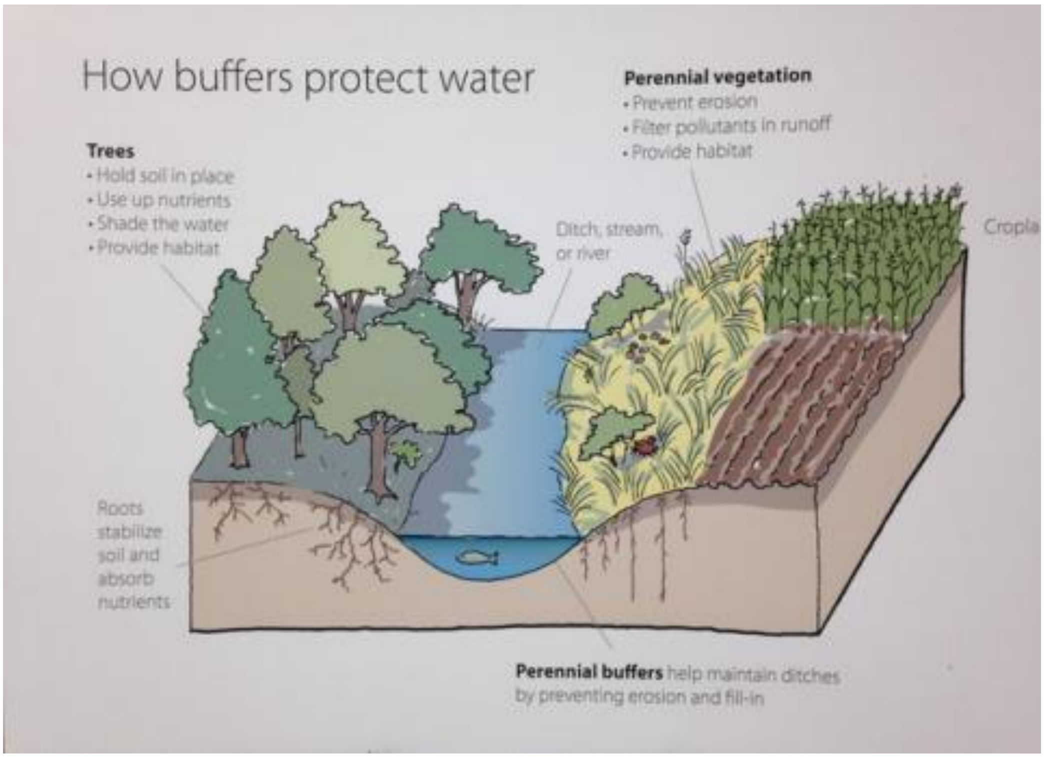


FIGURE 37. Buffer zone and its influence on water quality (Adam Uren, 2015)

9.3 Permeable paving

The idea is based on that there is less runoff on the pedestrian trails and riverside road. Thus, the permeable cushion lying above the embankment may be taken to reduce runoff.

9.4 Storm water ditches

Storm water ditches serve for collecting storm water and help transferring the water to the needed destination (such as filtering system, pumping station, etc.). It supports water purification and able to slow down or even decrease water runoff.

9.5 Green roofs

Green roofs allow purifying water at the top of the building. The water can be collected into a tank or go by pipe to the destination place for further reuse. Green roofs layers are shown in Figure 38. Figure 39 represents the comparison between traditional roof and green roofs.

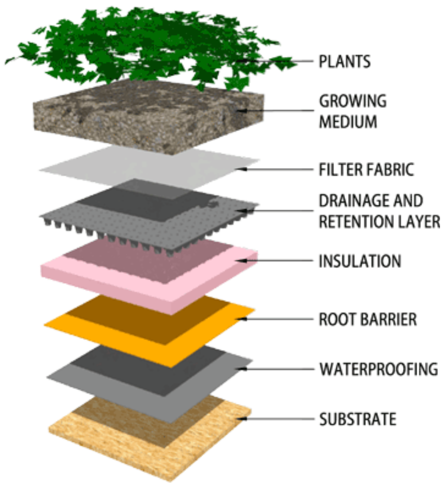


FIGURE 38. Green roof materials layers (Minnesota Green Roofs Council, 2015)

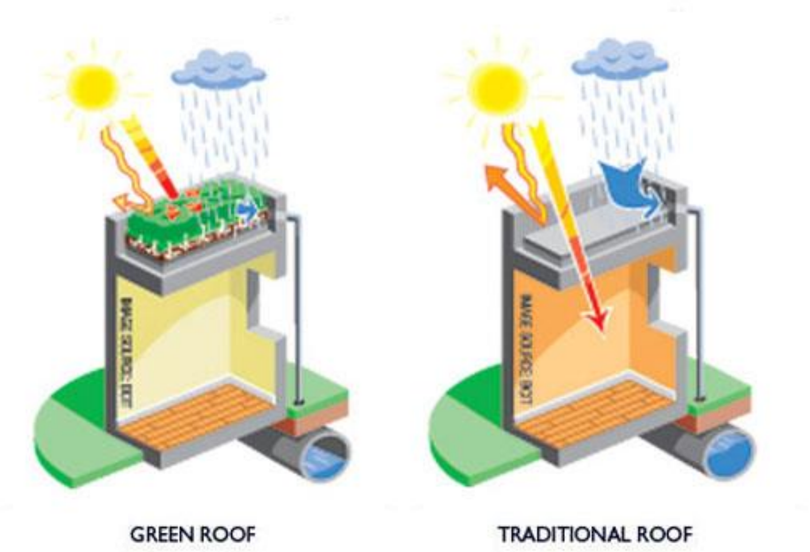


FIGURE 39. Green roof comparison (Intermountain Roofscape Supply, 2008)

Benefits of green roof:

- Greenhouse gas is produced when cooling demands are lowered;
- Reducing and slowing runoff of storm water;
- Improving indoor comfort by reducing heat transfer in a more comfortable temperature;
- Can act as an insulator for a building, reducing heating and cooling demand;
- Beautifying the environment;
- Becoming the inhabitant for many creatures.

9.6 Renovated streets

Constructing new and renovated streets, parking lots and sidewalks with interlocking stones, permeable paving and pervious concrete can be made (Figure 40). Figure 41 demonstrates the difference between pervious and impervious surfaces.

FIGURE 40. Green infrastructure (Lancaster Country Conserancy, 2016)

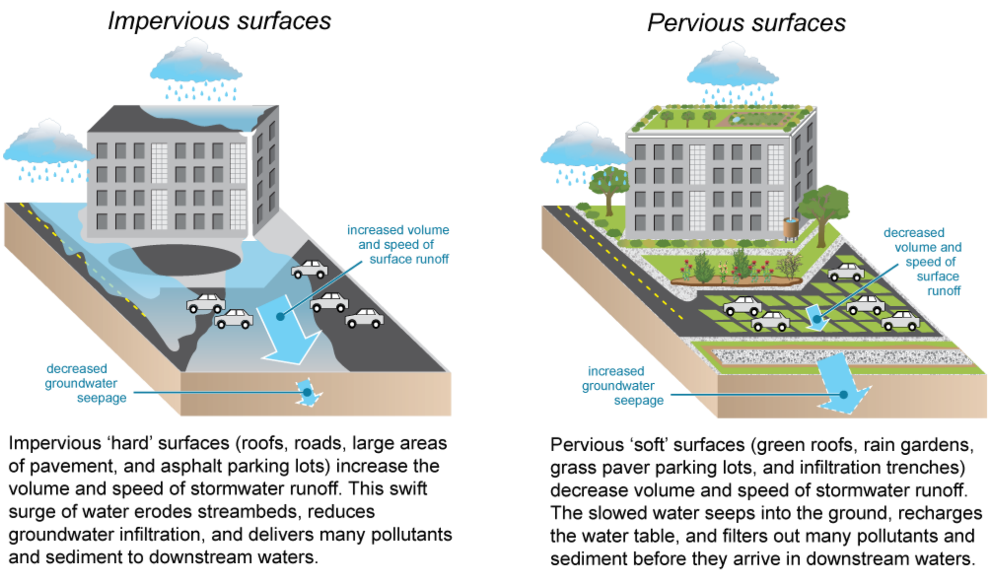


FIGURE 41. Comparison of pervious and impervious surfaces (World Resources Institute, 2012)

9.7 Midway runoff control

Midway runoff control is mainly about runoff stagnation, infiltration, storing or increasing the length of runoff routes which helps to increases the time and achieve purifying runoff water. These methods also help in reducing the load and store the pollutants for further removal and purification of water in the migration system by interception, sedimentation, adsorption, precipitation and other effects.

Some garbage which is not dissolved with water, such as comprising garbage and leaves, should be cleaned before rain.

The pollutants that have been washed away by runoff can be cleared with sewer deposition. Roof rainwater can recycle and use in water greenbelt, car washing, etc.

9.8 End centralized runoff control

Despite the source dispersion control and midway runoff control, there still have run-off after collection into the river. Therefore, the end centralized control should be implemented for further reducing of pollutants penetrating into the river. For this issue some ponds, park pools, artificial wetland and forest buffer zones can be built.

9.8.1 Designing wetland

As it was said before, wetlands can be made for end runoff centralized control. The proposed wetland involved two phases which have different design. It makes it more effective for treating nonpoint source pollution of this land and allows to reduce the concentration of ammonia, nitrite, T-P and T-N in outflow water. These two phases can be used together with each other as well as separately as individual units.

The whole design of suggested wetland includes six main units. They are:

1. Grit chamber

Grit chamber is designed to detain mineral impurities. The operating principle is based on the fact that specific gravity of particles is greater than the specific gravity of water. So, under the influence of the gravity, particles that move along with water will fall to the bottom of the tank. (Figure 42)

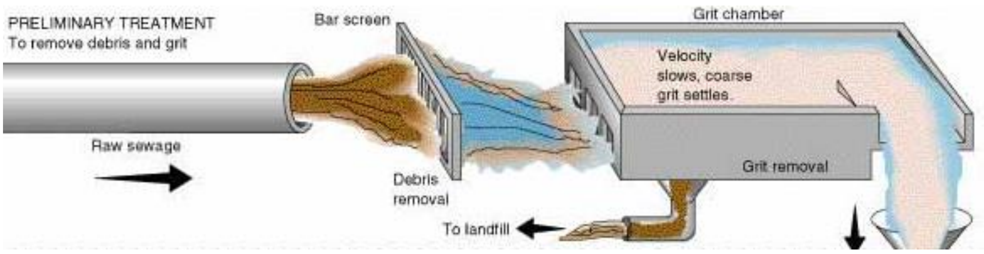


FIGURE 42. Grit chamber (Environmental Science Course)

2. Sedimentation tank

Sewage, after releasing from sand and bigger mineral suspended solids in grit chamber, are sent to the sedimentation tank, which is designed to detain much smaller solids by settling them down.

3. Biological pond

Biological ponds are artificially created ponds for biological wastewater treatment based on the processes that occur in the self-purification of water bodies. In biological pond some cress, water lily or water chestnut can be planted. (Figure 43)

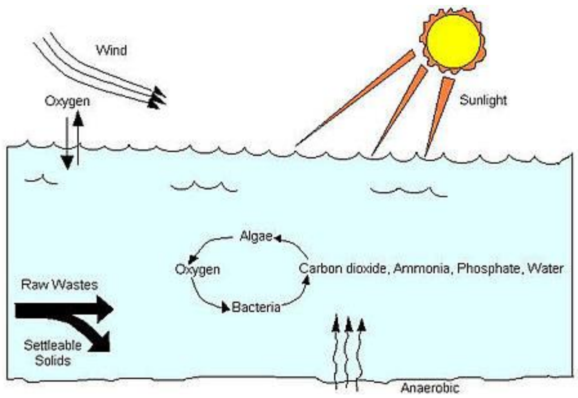


FIGURE 43. Oxidation pond (Stephi Poulose, 2015)

4. Subsurface oxidation pond

Subsurface flow systems do not have open water areas and constant level of water. These systems represent a filter bed filled with gravel, small stones, sand or soil, which is planted with aquatic plants, such as Reed, Cattail or Umbrella plant. (Figure 44)

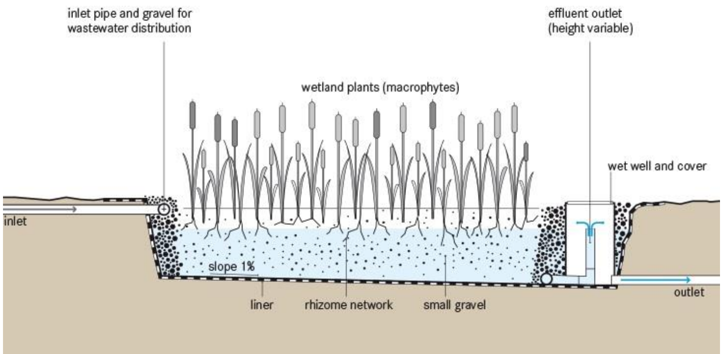


FIGURE 44. Subsurface oxidation pond (Swiss Federal Institute of Aquatic Science and Technology, 2014)

5. Surface flow wetland

System of surface flow is alike natural marshes with stagnant water and aquatic plants rooted in the soil. Waste water in such systems extends through the leaves, stems and base plants, such as Cress, Arrowhead, Lotus plants.

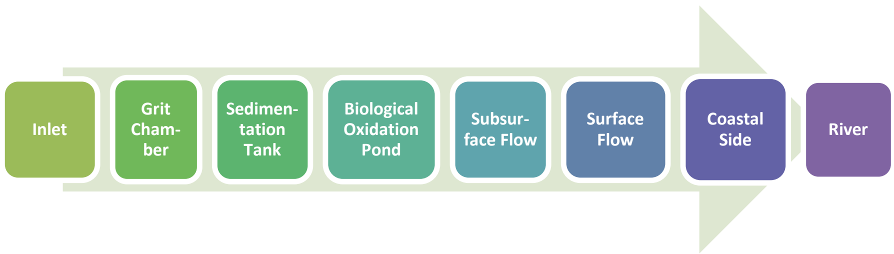
6. Coastal side

Coastal side can be either filled with gravel bank or planted by willow trees for the final filtration.

9.8.1.1 The wetland Phase 1

Table 17 represents process flow diagram. According to this diagram wetland treatment system receives the waste water into the grit chamber, which intends to reduce organic and solid loadings. After that, the sewage flows into precipitation tank and biological oxidation pond where it achieves further purification. In the middle of the treatment system there is subsurface and surface flow wetland unit. The subsurface flow wetland includes four parts, which set in a raw and provide continuous flow configuration. They should operate in parallel and be filled with gravel or cinder. At the end, the wastewater flows through coastal side and discharges into Lujiabang River.

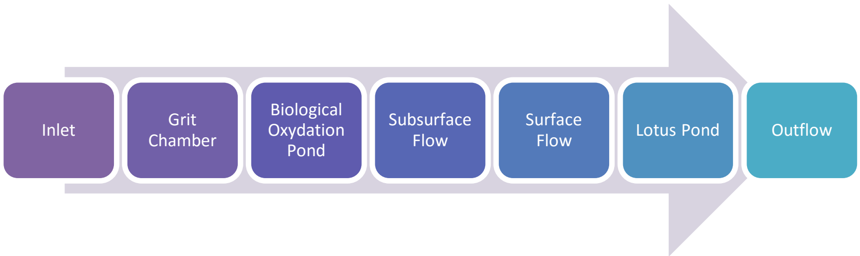
TABLE 17. Process flow diagram for Phase 1



9.8.1.2 The wetland Phase 2

The process flow diagram of the wetland is represented on Table 18.

TABLE 18. Process flow diagram for Phase 2



During not rainy days the wetland will receive the waste water inputs from Lujiabang ditch and the agricultural irrigation ditch. The main source of input water is agricultural runoff and domestic sewage.

9.9 Combined Sewer Overflow Tunnel

Based on project held in London of using green infrastructure for combined sewer overflow in Themes River, the idea of building tunnel for combined sewer overflow collection can be suggested for the case of Lujiabang River.

Even though combining sewage and storm water collection systems is a cost-effective solution for a city, with one operating pipe for both sewage and storm water streams, in case of heavy rain events, water can easily exceed the capacity of this system. This causes overflows that result in the discharge of a mixture of untreated storm water and sanitary sewage directly into the river, with negative environmental and public health consequences.

On figure 45 the process of sewage and rain runoff water flow in case of operating tunnel is schematically shown.

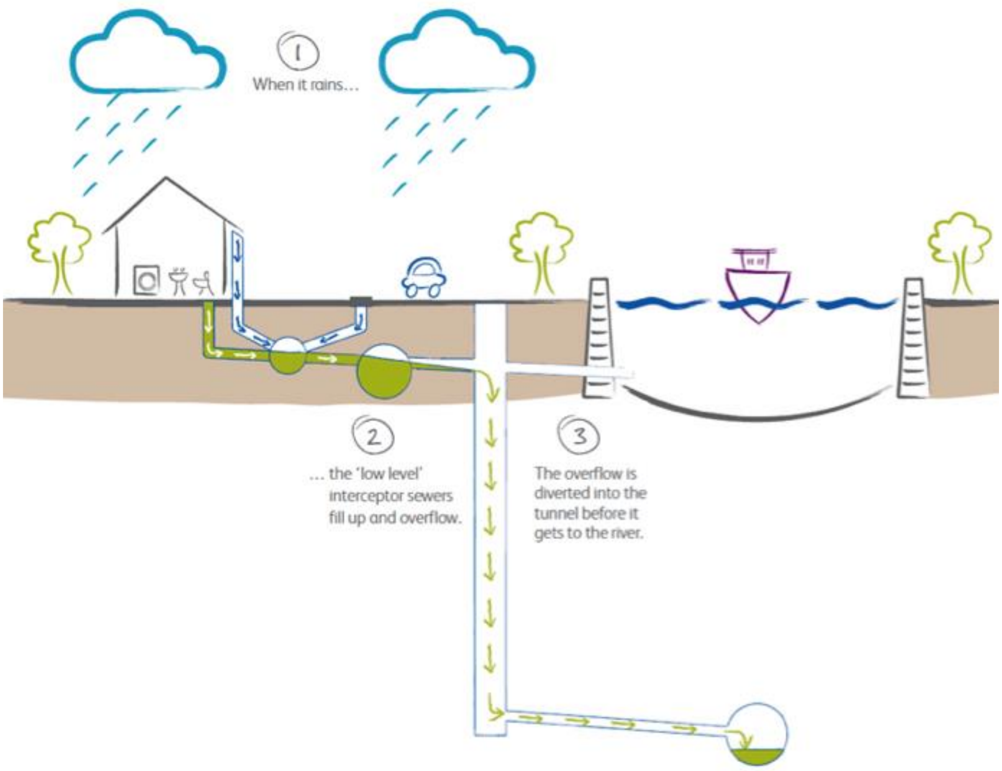


FIGURE 45. Schematics of proposed new tunnel for Combined Sewer Overflow collection (Horacio Terraza, 2013)

9.10 Additional ideas to be proposed

Communities may implement low impact development techniques to reduce flows of storm water into the collection system. This includes:

- Constant cleaning of roads and sidewalks from leaves, debris and other garbage
- Installing garbage bins along the road
- Guarding of gardening zones borders, excluding soil erosion during heavy rains to the road surface
- Do not wash in the river
- Do not throw garbage into the river
- Wash cars in specially designated areas (or on gravel, that also serves as water filter), use biodegradable or non-toxic soap that is phosphate-free
- Clean up pet waste

Mechanical method for river water cleaning:

- Motor-vessel refuse collectors for constant cleaning of river water

The cleaning can be made by fishing the garbage out from the water using nets. At first step the cleaning could be implemented by motor-vessel refuse collector. Special ships need to provide daily garbage cleaning from the river, which has come by flow or was thrown away by people, such as bottles, plastic bags or broken branches. In front of those ships should be a scoop-net which collects all the big garbage and does not keep the water. Then the waste should be put together into a big container on the deck. Everything that was not collected by the scoop should be picked up by hands.

10 CONCLUSION

Storm water is a major cause of water pollution in Kangqiao area of Pudong New District in Shanghai. In the rain, in unserved areas, the water is absorbed and filtered by the soil and plants. However, when the rain falls on roofs, streets and parking lots, the water cannot soak into the ground. So, most of not purified domestic wastewater and its untreated effluents are mixed with the storm water drainage system before the pump station, and discharged directly into Lujiabang River without any purification. Only the solid mater is filtered away with the screen after the pump station.

Storm water carries debris, bacteria, heavy metals and other pollutants from the city streets, deteriorating water quality. This high level of pollution end in river is high and the contaminated water badly influences on people living nearby as well as brings an impact on other rivers in Pudong area, partially polluting Yangzi River.

Thesis involves collected data about effect of rain runoff and sewage on Lujiabang River and other rivers in Pudong New Area, which are taken as the standard for demonstrating water pollution in this area, as well as comparison between Chinese and Russian water quality status data is represented, according to the water legislation of these two countries and finally after giving a brief analysis of results, suggests methods for improving water quality environment of Lujiabang River.

Two suggested methods for purifying water in Lujiabang River are based on grey and green infrastructures. Comparing two of these infrastructures emphases has been placed on green infrastructure as it can help in reducing storm water runoff in a cost-effective way, but it may also be an essential tool in designing a more sustainable urban landscape and key component in improving the general welfare of population.

One of the directions of thesis is based on the course studied at Shanghai Polytechnic University, which teaches the protection of water resources with the implementation of new technological processes of production, moving to closed water cycle, where the effluent is not discharged, and repeatedly used in industrial processes. Closed loops of industrial water supply will allow a complete elimination of waste water discharged into surface water and fresh water used to replenish the deadweight losses.

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