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WATER QUALITY MONITORING

Dongjiang River Basin

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Task1: Why it monitoring? Objective of the WQ monitoring

1.1 Introduction

1.1.1 Study Area

The Dongjiang River (also known as East River in English) locates between 113°5”-115°5” E and 22°3”-25°1” N, which is one of the three major branches of the Pearl River (Zhujiang) in South China. The river originates from Xunwu County in Jiangxi province, flows south-west to in Guangdong and discharge into the South China Sea, as shown in figure 1. The drainage area is approximately 35,340 km^2, while 90% of the area locates in Gangdong Province and the main river channel is 562 km long. More important, the Dongjiang River is the primary water source for agricultural irrigation, industrial water and drinking water in the Pearl River Delta and Hong Kong (*Yang et al.*, 2018).

1.1.2 Dongjiang-Shenzhen Water Supply project

To meet the increasing drinking water demand of Hong Kong people, the Governments of Guangdong Province and Hong Kong proposed the Dongjiang-Shenzhen Water Supply Project (DSWS) in 1963. This project pumps the freshwater from Dongjiang River in Qiaotou town of Gongguan and transfers by pipelines and tunnels along the Shima River to Hong Kong (Figure 1) *(Hong Kong WSD, 2020).*

In 2003, The Guangdong authorities built a specific tunnel to extract water from Shenzhen Reservoir that recharges from Dongjiang River due to serious water pollution in the major river of Dongjiang river basin. This operation significant improves in Dongjiang water quality as received in Hong Kong *(Hong Kong WSD, 2016).*

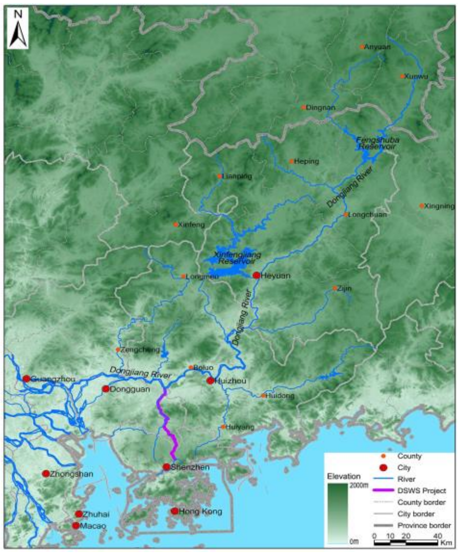

Figure 1 Map of the Dongjiang River

1.2 The relevant authorities and legal basis for WQ monitoring in the river basin

In the study, there are many authorities identified who have responsibilities for water quality, based on the paper of *Yang et al. 2018,* as shown in Table 1, and the authorities, who play a crucial role in monitoring water quality, are mentioned.

The following authorities play an essential role in water management with different responsibilities to monitor water quality. **(1)Municipal (county) governmental institutions**: the control of the water pollution and the seeking of water resources in their territory; **(2)Dongjiang River Commission Board:** responsible for all water issues in the Dongjiang River basin; Assist different municipal governments to deal with water issues across administrative boundaries; Report water issues to GangDong Provincial Water Bureau; **(3) GDH Water Supply Company:** supply the drinking water and transfer services to Hong Kong and Shenzhen; monitor the water quality of Dongjiang river because of Dongjiang-Shenzhen Water Supply project.

Table 1 **Authorities table: the key players who have a high demand for water quality monitoring.**

Category	Institutions	Level*	Significance
Government	Ministry of Water Resources, PR China	National	
	Department of Ecology and Environment of Guangdong Province	Provincial	
	Municipal (county) governmental institutions	Municipal	key player
Water department	Pearl River Water Resources Commission[1]	Regional (Pearl River)	
	Dongjiang River Water Resources Commission	Provincial	key player
	Municipal water / environmental protection departments	Municipal	
Water company[2]	GDH Water Supply Company	Provincial	key player
	Water supply companies in the cities/counties	Municipal	

* The level is used to distinguish the authority hierarchy and authorities who have a higher hierarchical governance level can influence the lower institution behavior. However, the municipal government has a strong influence on Dongjiang River, because the provincial or national government generally focus on the inter-regional drinking water distribution.

[1] Water Resources Commission is the individual government agency to manage the water quality issues of a specific river, which is independent of the local government and under the jurisdiction of Water Resources Commission of the main river basin or the Ministry of Water Resources

[2] Water company is the state-owned enterprise in China, which belongs to government administrators due to the chairman of the company appointed by the government. Thus it also has the right to influence the water policy.

According to the requirement of the Dongjiang River Water Resources Commission, Water quality in Dongjiang River complies with the standard values of GB3838-2002 Type III, called ***Environmental Quality Standards for Surface Water*** *(SEPA, 2002).* Meanwhile, the Hong Kong government uses the World Health Organization's ***Guideline for Water Quality*** *(WHO, 2006)* and GB3838-2002 to compare the drinking water quality. Interestingly, the China standard is much stricter than the WHO standard.

Meanwhile, the frequency of monitoring the quality of supply water refers to ***Water Quality Standards for Urban Water Supply***(CJ/T 206-2005)(*TWSA*, 2005), and ***Discharge Standard of Pollutants for Municipal Wastewater Treatment Plant*** clearly indicate the standard of water quality of domestic effluents *(MEEPRC, 2002)*. The water quality of industrial wastewater complies with ***Discharge Standard of Water Pollutants for Xiao Dongjiang River*** *(DEEGD, 2019)*.

1.3 Key questions related to water quality

1) Water pollution due to soil erosion from the abandoned rare earth mines in upstream of Dongjiang River, as shown in fig.2. There is one of the largest rare earth mines in China located in Xunwu County, which is the original regions of Dongjiang River. Unfortunately, the acid heap leaching method, applied in rare earth mining, injects a large number of acidic substances into the soil, resulting in a massive acidity in the water body because of soil erosion or solution leakage. The pH values of some river sections are lower than 3 (neutral is 7), and the groundwater also becomes acidic, which is not drinkable(*L WANG et al.*, 2014).

2) Non-point source pollution from fertilization for rice cultivation in the mid-stream of Dongjiang river basin, as shown in fig.2(*Lin et al.*, 2012).

3) A large number of contaminants released from the industrial and domestic effluents in the downstream. About 60% of industrial and domestic wastewater is not treated effectively before discharge(*Jiang et al.*, 2012). Moreover, fig.2 presents the location of the industrial area of Huizhou, and this area has multiple electronic information industrial parks and the largest manufacturing base of lighting appliances in China. Those lead to severely industrial pollution water discharging into the Dongjiang River in Huizhou(*R Wang et al.*, 2012).

1.4 Information to address questions

1) The Xunwu government reduced soil erosion by engineering measures to strengthen the soil, and then thoroughly treated it with biological measures (e.g. planting many types of plants). It also used a new technology, called ionic rare earth resources, to reduce acid leakage(*Cheng and Li*, 2012).

2) The only way to reducing this non-point source pollution is decreasing the amount of fertilization and limit the area of arable land.

3) The department of ecology and environment of Guangdong Province already published *Regulations of Guangdong Province on Water Pollution Control* in 2019*(DEEGD, 2019),* and factories, which the industrial wastewater effluents don't strictly *follow the discharge standard of water pollutants for Xiao Dongjiang River* (DEEGD, 2019), are punished.

4) Moreover, municipal (county) governmental institutions are to strengthen supervision the discharge of domestic wastewater, which must obey the discharge standard of pollutants for municipal wastewater treatment plant *(MEEPRC, 2002).*

1.5 Conceptual model and missing information

The conceptual model shows in fig.2. Unfortunately, it is an information that the exact area and location of rare earth mine cannot find. Thus, the author drew an approximate area in the model. Meanwhile, the processes necessary to contaminant discharge describe in the following three parts of the river basin.

(1)Upstream: The rare earth element dissolute into Dongjiang River due to the soil erosion from the rare earth mines. Meanwhile, a large amount of acidic matter, including sulphate and ammonia, injects into the soil for mining the rare earth results in the leakage of the acidic solution to groundwater. And then groundwater discharge into Dongjiang River.

(2)Mid-stream: The fertilizer used to cultivate paddies leaks into the groundwater leading to the existence of the high nitrogen and phosphorus concentration in mid-stream of Dongjiang River.

(3)Downstream: The industrial and domestic wastewater effluents transfer by sewages and directly flows into the Dongjiang River.

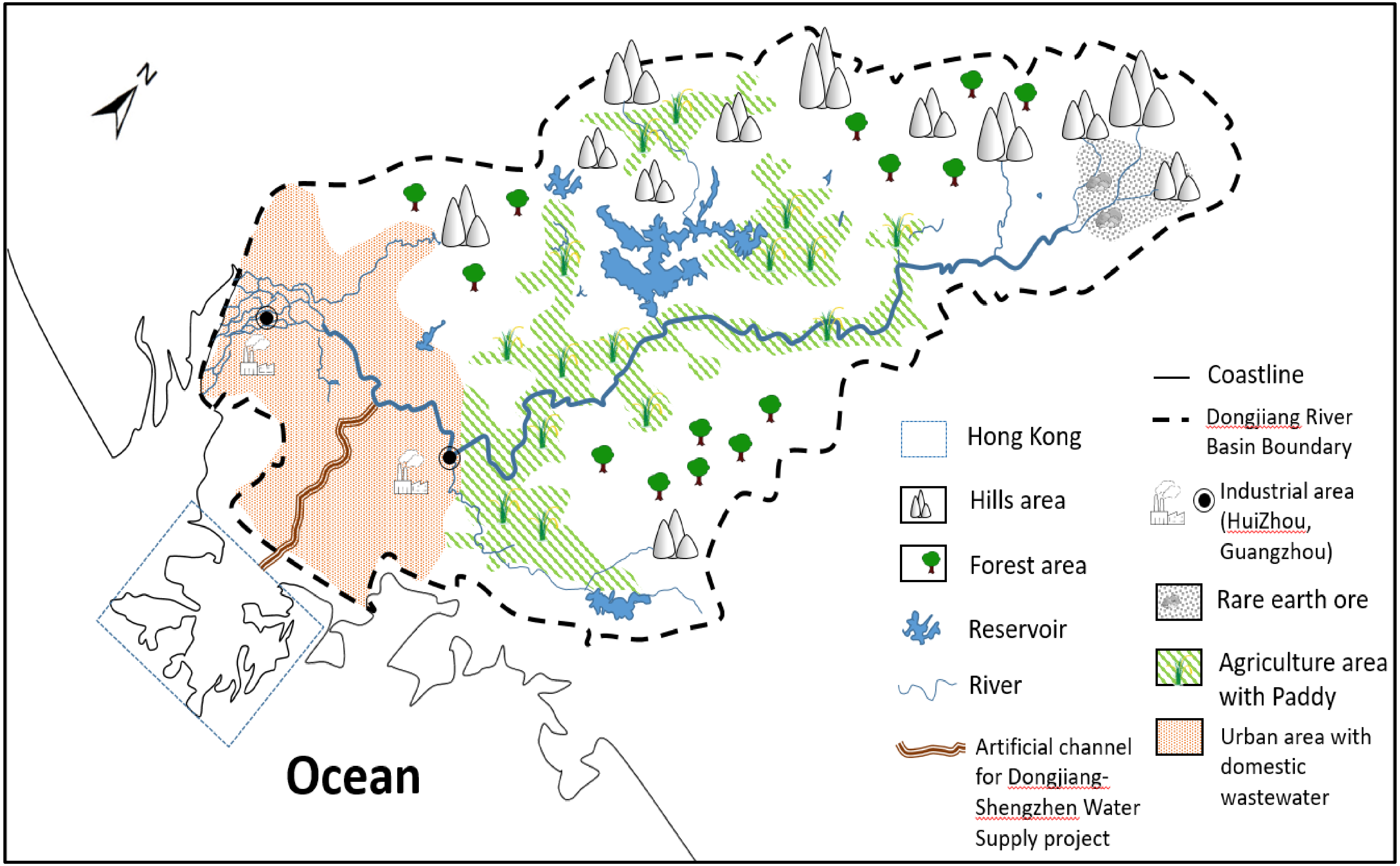

Figure 2 Conceptual model of Dongjiang river basin

1.6 Objectives for the monitoring program

Water quality monitoring program of this paper is to ensure the security of Hong Kong people's drinking water quality, which is a responsibility of GDH Water Supply Company. There are four sub-objectives for this program to ensure water quality of Dongjiang River complied with the standards of GB3838-2002 Type III *(SEPA, 2002)* and water quality in Shenzhen reservoir obeyed with *Guideline of Water Quality (WHO, 2006).*

1) Heavy metal and acid pollutions from rare earth mines are monitored in the upstream to protect health of human; 2) Monitoring fertilization pollutions from agriculture area, which may lead to algal blooms, are necessary in mid-stream; 3) Industrial effluents in Huizhou are monitored in downstream to Prevent illegal discharge of sewage; 4) Monitoring the domestic wastewater in downstream is useful to decrease risks of infectious diseases.

Task 2: Where to monitor?

2 Location of monitoring stations

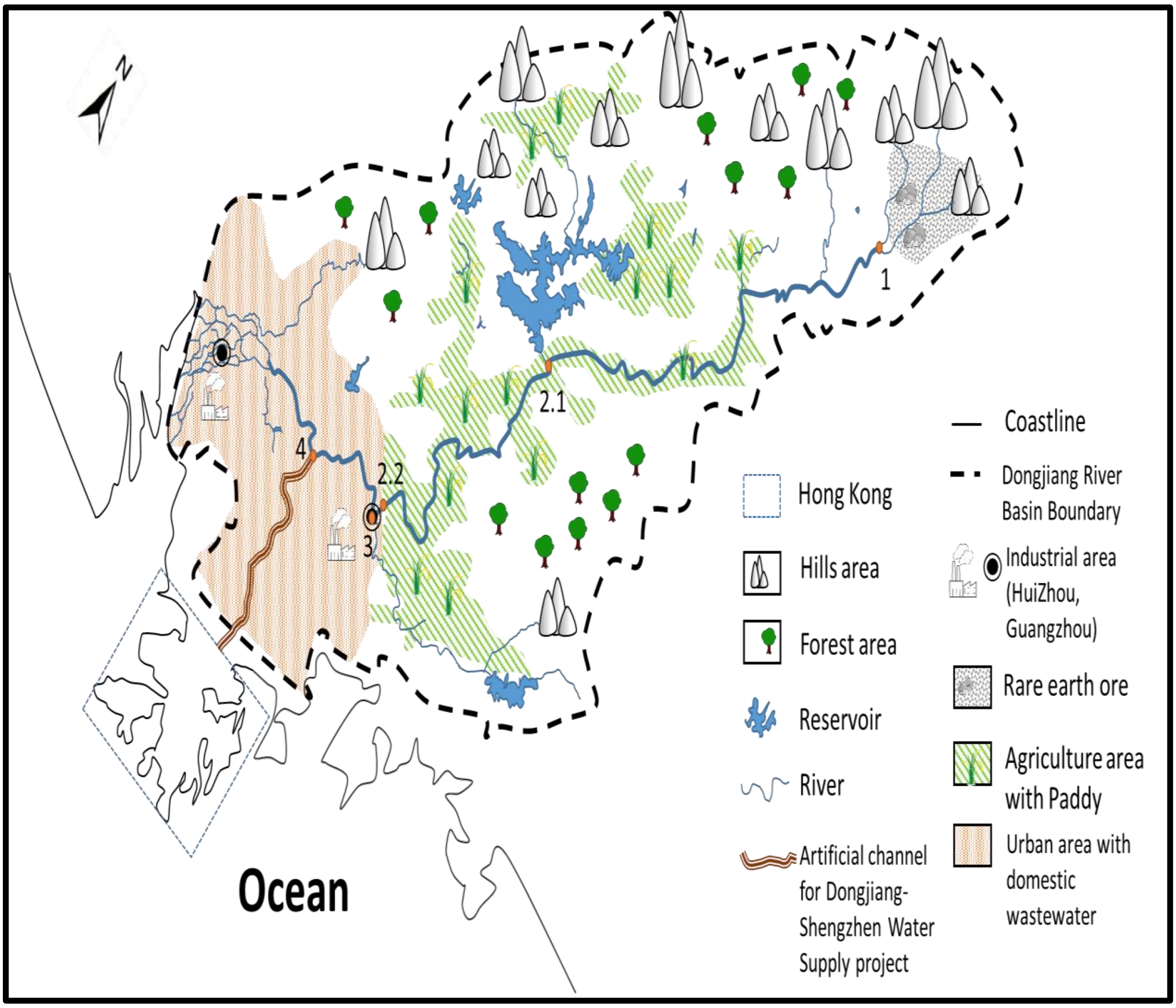

Figure 3 location of stations on the conceptual model

Figure 3 presents the locations of the station for WQ monitoring on the conceptual model and the explanations for the number and configuration show in table 2. Moreover, there are six WQ stations and two discharge gauging stations divided into four groups in three areas.

Table 2 the number and configuration of location of stations

Category	Group	Station	Explanation
Upstream	1	A WQ monitoring station /A Discharge gauging station	No.1 station set at the downstream of the rare earth mines and upstream of the agriculture area, as shown in fig.3. This operation can focus on the contaminants from the soil erosion and prevents the influence of fertilizer pollution due to paddy cultivation. As for the discharge gauging station, it is used to identify the wet/dry season[1].
Mid-stream	2.1	Two WQ monitoring stations	One of No.2.1 stations set at the confluence of Dongjiang River and Xingfangjiang Reservoir to monitor the agricultural pollution from the upstream of the reservoir, and another station set at the upstream of the two rivers' confluence to monitor the contaminants leakage from the agricultural areas to Dongjiang River's upstream.
	2.2	A WQ monitoring station	No.2.2 station set at the boundary between the agricultural area and the urban area, which concentrates on the pollution from the downstream of the rice cultivation area.
Downstream	3	A WQ monitoring station /A Discharge gauging station	No.3 station set at the discharge place of the industrial area to monitor the industrial pollution. As for the discharge gauging station, it is used to identify the wet/dry season[1].
	4	A WQ monitoring point	No.4 station set at the entrance of artificial tunnels* of DSWS project to monitor the domestic wastewater pollution.

* artificial tunnels has the specific aim for the drinking water supply to Hong Kong and other cities (e.g. Shenzhen) along the pipelines. Thus, the tunnels are contaminated less from the point source of pollution in urban areas due to that the discharges of domestic wastewater is not allowed.

[1] Dongjiang River basin has wet (April-September) and dry (October-March) season due to placing at subtropical monsoon zone with mean annual precipitation of 1750 mm. Under the monsoon climate, 70%-80% of rainfall and runoff occurs during the rainy season(*Lin et al.*, 2012)

Task 3: When to monitor?

3 Schedule of monitoring activities

The different monitoring activities have different frequencies, and table 3 present the frequencies of stations and its explanation.

Table 3 the frequencies of stations and its explanation

Category	Group	Frequency	Explanation
Upstream	1	1) Twice per month in the wet season(April-September) 2) Once per month on other months	This station aims to monitor the pollution from the rare earth mines and the frequency of monitoring is monthly according to the frequency standards(*TWSA*, 2005). However, the river in high flow accelerates soil erosion which contains heavy metal contaminant in rainy season and the frequency rises to twice per month.
Mid-stream	2	1) Twice per month on April, June, August and October 2) Once per month on other months	All three stations site in the agricultural area to monitor the pollution of fertilization. The frequency of monitoring is once per month due to the leakage of non-point-source pollution from the farm. However, according to the agriculture survey in this area, there are two-season paddies cultivated and two periods of fertilization at each crop season. Moreover, the averaged amount of total fertilizer applied was around 140 kg/ha/a with 70 kg/ha for two seasons beginning in April and August (*Wu and Chen*, 2013). Thus, the months, including April, June, August and October, need to rise the monitoring frequency according to the fertilizer requirement of rice (*P Wang et al.*, 2009).
Down-stream	3	1) Twice per month in the dry season(October-March) 2) Once per month on other months	For obtaining profits, the industries in the downstream keep working every day and contaminants released in industry area need to monitor monthly according to Water Quality Standards for Urban Water Supply(CJ/T 206-2005)(*TWSA*, 2005). However, the Dongjiang River in low flow are more influenced by point-source pollution from industrial wastewater effluents in the dry season (*Lin et al.*, 2012) and the frequency of monitoring in dry season increase to twice per month.
	4	Daily	According to Water Quality Standards for Urban Water Supply(CJ/T 206-2005) (*TWSA*, 2005), the number of coliform group and the total bacterial count are required to monitor daily to decrease risks of infectious diseases and ensure the safe discharge of domestic wastewater.

Task 4: What to monitor?

4 Parameters to be monitored at each station

Table 4 shows that the parameters of water quality need to be monitored and their explanation with four groups in three different areas.

Table 4 Parameters to be monitored and their explanations

Category	Group	Parameter	Explanation
Upstream	1	Base parameters: Temperature(T), Electrical Conductivity(EC), Dissolved Oxygen(DO)* Additional parameters: **(1)** pH; **(2)** Ammonia Nitrogen(NH3-N); **(3)** Cadmium(Cd) and Lead (Pb)	According to the survey of the environment of XunWu county before the period of governing soil erosion, the harmful elements in soil erosion from the rare earth mines are mainly Pb, Cd, etc., and the tailings pond wastewater contains Pb as high as 14 mg / L, and Cd 0.024mg / L. The ammonia nitrogen and sulphate content in the mining area and downstream water also often exceed the standard, resulting in drinking water difficulties for more than 30,000 people and over 400 acres of farmland will be reduced or cut off. Moreover, the pH values of some river sections are lower than 3 (neutral is 7) *(Cheng and Li, 2012)*. Thus those additional parameters need to monitor.
Mid-stream	2	Base parameters: Temperature(T), Electrical Conductivity(EC), Dissolved Oxygen(DO) Additional parameters: **(1)** Nutrient parameters (total phosphorus (TP), total nitrogen (TN), ammonia nitrogen (NH3-N))	Nutrient parameters are total phosphorus, total nitrogen and ammonia nitrogen, which reflect the level of trophic, and the river may cause eutrophication if those parameters exceed the standard (*Wu and Chen*, 2013). However, the most problem in the agricultural area is the fertilizer leakage resulting in the eutrophication of the river. Thus, monitoring the additional parameters is necessary.
Downstream	3	Base parameters: Temperature(T), Electrical Conductivity(EC), Dissolved Oxygen(DO) Additional parameters: **(1)** Biochemical Oxygen Demand(BOD), Ammonia Nitrogen(NH3-N), Organo-nitrogen(org-N), Total Nitrogen(TN), Metal phosphorus(min-P), Organo - phosphate(org-P),Total phosphorus(TP); **(2)** Mercury(Hg) and Iron(Fe).	Biochemical Oxygen Demand(BOD), Ammonia Nitrogen(NH3-N), Organo-nitrogen(org-N), Total Nitrogen(TN), metal phosphorus(min-P), Organo-phosphate(org-P), Total phosphorus(TP) are the parameters to indicate the level of industrial point-source pollution in China (*Wu and Chen*, 2013). According to the several papers related to water quality in the study area, mercury (Hg) and iron (Fe) have high concentrations in the downstream (*Jiang et al.*, 2012; *R Wang et al.*, 2012). Unfortunately, high concentrations of mercury may result primarily in haemorrhagic gastritis and colitis, and final the ultimate damage is to the kidney(*WHO*, 2011). To sum up, it is essential to monitor the additional parameters.
	4	**(1)** Total Coliform Bacteria (TCB) and Total Plate Count (TPC)	According to Water Quality Standards for Urban Water Supply(CJ/T 206-2005) (), the number of coliform group and the total bacterial count is required to monitor daily to decrease risks of infectious diseases and ensure the safe discharge of domestic wastewater.

* Base parameters are useful for monitoring the water quality of the river. The electrical conductivity reflects the amount of the sum of cation and anion and high dissolved oxygen is beneficial to the degradation of various pollutants in the water body so that the water body can be purified faster.

Task 5: Prepare a budget for the establishment of your monitoring network and an annual operational budget.

Budget Indications:
Staff time = €50 / day
Staff per diem = €40 / day
Vehicle use = €100 / day
River discharge gauging station = €5000 / station
Annual maintenance of discharge station = €300 / station
WQ materials and supplies = €25 / station / sampling
Note: For analytical costs see file "Laboratory Analysis Price List"
For any other costs you anticipate indicate a reasonable value based on your research

Table 5.1 Budget for the establishment of your monitoring network

Category	Group	Number of WQ monitoring station	Frequency per yr	Staff for sample collection	Number of discharge station	Staff fee	Vehicle use	Discharge station price	Total price
Upstream	1	1	12+6	1	1	$1,620	$1,800	$5,000	$8,420
Mid-stream	2	3	12+4	1		$4,320	$4,800		$9,120
Downstream	3	1	12+6	1	1	$1,620	$1,800	$5,000	$8,420
	4	1	365	1		$32,850	$36,500		$69,350
								Total price of the establishment of monitoring network:	**$95,310**

Table 5.2 Annual operational budget

Category	Group	Item code	Parameters	PRICE incl. GST	Amount	Frequency per yr	Total Price incl. GST
Upstream	1	SW-SING-060 SW-SING-056 SW-SING-058	Temperature Electrical -Conductivity Dissolved Oxygen	$33	1	18	$594
		SW-SING-055	pH	$11	1		$198
		SW-SING-047	Ammonium	$22	1		$396
		SW-PREP-002 SW-SING-104	Total Available / Acid Soluble Metals General Metals - Total Available / Acid Soluble(**Cd & Pb**)	$16.5	2		$594
Mid-stream	2	SW-SING-060 SW-SING-056 SW-SING-058	Temperature Electrical -Conductivity Dissolved Oxygen	$33	3	16	$1,584
		SW-SING-053 SW-SING-052 SW-SING-047	Phosphorus - Total (TP) Total Nitrogen (TN) Ammonium	$88	3		$4,224
Downstream	3	SW-SING-060 SW-SING-056 SW-SING-058	Temperature Electrical -Conductivity Dissolved Oxygen	$33	1	18	$594
		SW-SING-110 SW-SING-047 (Missing) SW-SING-052 SW-SING-065 SW-SING-053 SW-PREP-002 SW-SING-104	Biochemical Oxygen Demand (BOD) - Dissolved Ammonium Organo-Nitrogen(Org-N) Total Nitrogen (TN) Organo-phosphates (OP) Phosphorus - Total (TP) Total Available / Acid Soluble Metals General Metals - Total Available / Acid Soluble(**P**)	$297	1		$5,346
		SW-PREP-002 SW-SING-104	Total Available / Acid Soluble Metals General Metals - Total Available / Acid Soluble(**Hg & Fe**)	$16.5	2		$594
	4	SW-SING-040 SW-SING-046	Bacteria - Total Coliforms Total Plate Count	$88	1	365	$32,120
WQ materials and supplies				$25	6	449	$11,225
Annual maintenance of discharge station				$300	2	1	$600
				Total price of Annual operation:			**$58,069**

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