REGIONAL OVERVIEW

Assessment of trends in river and direct inputs of contaminants to the marine and coastal environment in the NOWPAP region

NOWPAP POMRAC

Northwest Pacific Action Plan
Pollution Monitoring
Regional Activity Centre

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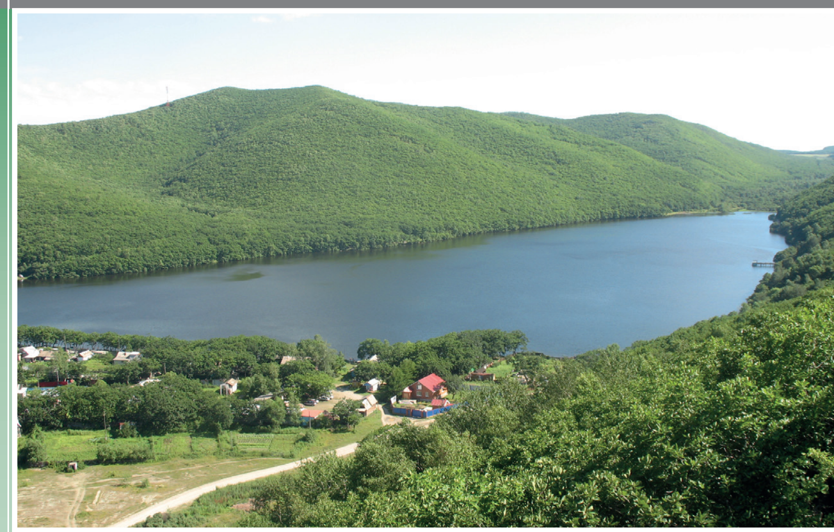

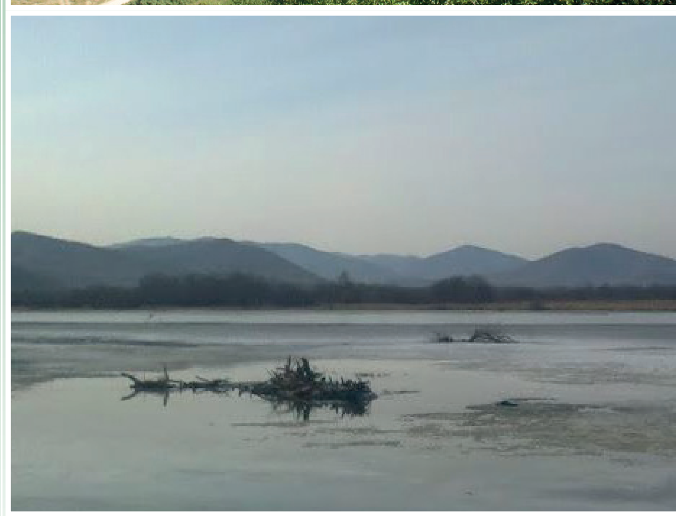

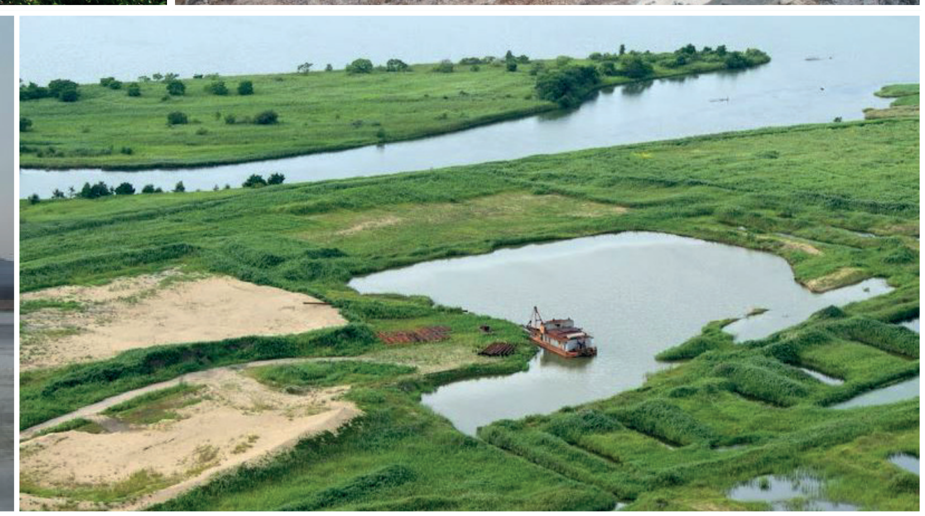

POMRAC Technical Report No 15

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POMRAC, Vladivostok, Russian Federation
2019

POMRAC Technical Report No 15

Pollution Monitoring Regional Activity Center of UNEP Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP POMRAC)

Региональный Центр по мониторингу загрязнения окружающей среды Плана действий ЮНЕП по охране, управлению и развитию морской и прибрежной среды в регионе северо-западной Пацифики (NOWPAP POMRAC)

Pacific Geographical Institute, Far Eastern Branch of the Russian Academy of Science

Федеральное государственное бюджетное учреждение науки Тихоокеанский Институт Географии Дальневосточного отделения РАН

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Оценка тенденций изменения выноса загрязняющих веществ реками и сточными водами в прибрежно-морские акватории северо-западной Пацифики. Региональный обзор / авторы: В.М. Шулькин, Се Син, О. Матсуда, Ж. С. Кхим; отв. Редактор: А.Н.Качур. – Владивосток: ТИГ ДВО РАН, 2019. – 80 с.

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List of acronyms

ABS	– Acrylonitrile butadiene styrene
BOD	– Biological oxygen demand
BTs	– Butyltins
Chl-a	– Chlorophyll a
CHLs	– Chlordanes
COD	– Chemical oxygen demand
DDTs	– Dichloro-diphenyl-trichloroethane
DIN	– Dissolved inorganic nitrogen
DIP	– Dissolved inorganic phosphorus
DO	– Dissolved oxygen
FMRP	– Four Major River Project
KECO	– Korea Marine Environment Management Corporation
MEIS	– Marine Environmental Information System
MOE	– The Ministry of Environment (ROK)
NGO	– Non-governmental organization
NH3-N	– Ammonia-Nitrogen
NIER	– National Institute of Environmental Research (ROK)
PAHs	– Polycyclic aromatic hydrocarbons
PCBs	– Polychlorinated biphenyls
PHC	– Petroleum hydrocarbons (oil pollution)
SMA	– Special Management Area
SS	– Suspended solid

TMS	– Telemonitoring system
TN	– Total nitrogen
TOC	– Total organic carbon
TP	– Total phosphorus
TPLMS	– Total Pollution Load Management System
TWPLMS	– Total Water Pollution Load Management System
VOCs	– Volatile organic compounds
WQI	– Water quality index
WQS	– Water quality standard
UNDP YSLME	– United Nations Development Program Yellow Sea Large Marine Ecosystem
PICES	– North Pacific Marine Science Organization
GDP	– Gross Domestic Product
CNEMC	– China National Environmental Monitoring Center (China)
MEE	– Ministry of Ecology and Environment (China)
SEPA	– State Environmental Protection Agency (China)
MPD	– Maximum Permissible Discharges of wastes (Russia)
MDL	– Method detection limit
PGI FEB RAS	– Pacific Geographical Institute Far Eastern Branch Russian Academy of Sciences
FEGI FE BRAS	– Far East Geological Institute Far Eastern Branch Russian Academy of Sciences
SCWPI	– specific combinatorial water pollution index

1. Executive Summary

River and direct inputs of chemical substances continue to be very important factors related to many environmental problems in marine and coastal areas. This is the reason why preparation of the *Regional Overview on River and Direct Inputs of Contaminants into the Marine and Coastal Environment in the NOWPAP Region* (hereinafter RDI RO) was one of the initial activities of POMRAC. First RDI RO has been published in 2006 (POMRAC Technical Report #4) and was based on the data of 2002-2004. Next RDI RO has been published in 2009 (POMRAC Technical Report # 7) and summarized the available data for 2005-2207. The necessity to update this information is obvious, especially taking into account the effects of global changes. This is a reason of the proposal to prepare new regional assessment of trends in river and direct Inputs of contaminants to the marine and coastal environment in the NOWPAP region during the last decade. This activity was suggested at the 14th POMRAC FPM, and approved by 21 IGM in 2017.

This Regional Overview, based on the recent available data for 2007-2016 presented by the experts from the NOWPAP member states, summarizes the status and trends during the last decade of river water quality and data on direct input of contaminants. NOWPAP publications, research papers, and overviews prepared by other international projects such as UNDP YSLME and PICES, are also used.

Natural environmental conditions and main socio-economic factors in China, Japan, Korea, Russia within NOWPAP region are briefly described as part of the analysis of natural and anthropogenic factors affecting inputs of chemical substances to the sea. Population in the NOWPAP region is very unevenly distributed. Population density ranges from 11 people/km^2 in Russia to 486 people/km^2 in Korea. The GDP per capita in the NOWPAP Region is also variable.

The major features of legal background for the monitoring of natural waters and effluents quality in the NOWPAP countries are briefly presented in this overview. The report also describes the existing monitoring networks, responsible agencies, methods and criteria used. The main criteria of water quality in all NOWPAP countries are based on compliance with a set of the norms or standards. Similarities and differences in standards, approaches, and methods used are also outlined and measures to overcome some incompatibility are suggested.

The river water quality and ecological problems of the coastal areas due to input of contaminants from the land-based sources continue to be among the main issue in the NOWPAP region (SOMER, 2008, 2014, YSLME, 2008). This overview summarizes the status and trends of river water quality based on monitoring results for the last two decades. Possible reasons of the existing trends are suggested and discussed. Discharge quantity for major rivers is calculated and hence the pollution load for the sea area of the NOWPAP region can be estimated. The status and temporal trends for chemical substances in river water are also described.

Direct inputs of contaminants are discussed in this overview dualistically: narrowly as amount delivered with wastewaters by the point outfalls to the sea, and more broadly as volume of contaminants in wastewaters generated and released at the anthropogenic activities on the watersheds. Latter is necessary if we want to assess in holistic way the anthropogenic impact on the NOWPAP sea areas.

2. Introduction

2.1. Background

Regular assessment of the state of the marine environment is one of the major goals of UNEP NOWPAP as a whole, and NOWPAP POMRAC in particular. Proposed new NOWPAP Medium-term Strategy (MTS 2018-2023) also includes regular assessments as a key activity. River and direct inputs of chemical substances continue to be very important factors related to many environmental problems in marine and coastal areas. This is the reason why preparation of the *Regional Overview on River and Direct Inputs of Contaminants into the Marine and Coastal Environment in the NOWPAP Region* (hereinafter RDI RO) was one of the initial activities of POMRAC. First RDI RO has been published in 2006 (POMRAC Technical Report #4) and was based on the data of 2002-2004. Next RDI RO has been published in 2009 (POMRAC Technical Report # 7) and summarized the available data for 2005-2207. The necessity to update this information is obvious, especially taking into account the effects of global changes. This is a reason of the proposal to prepare new regional assessment of trends in river and direct Inputs of contaminants to the marine and coastal environment in the NOWPAP region during the last decade. This activity was suggested at the 14th POMRAC FPM, and approved by 21 IGM in 2017.

2.2. Goals and tasks

The major goal of this overview is to present recent information on the river and direct inputs of chemical substances to the coastal sea within NOWPAP region and to estimate possible trends during the last decade. This goal is closely connected with analysis of existing monitoring schemes and methods used in the NOWPAP countries. Comparison of the monitoring schemes and methods, including the environmental standards and norms is the second major goal of this project.

The overview is based on the compilation of National Inputs prepared by the nominated experts from all NOWPAP countries along with analysis of the previous NOWPAP POMRAC Regional overviews on river and direct inputs (POMRAC Technical Report # 4, #7). Ms. Xin Xie (China National Environmental Monitoring Center), Prof. Osamu Matsuda (Japan), Dr. Jong Seong Khim, (Seoul National University, Republic of Korea), and Dr. Vladimir Shulkin (Pacific Geographical Institute, Russia) have prepared the National Inputs, and Dr. Vladimir Shulkin has compiled the Regional Overview.

2.3. General information on geographical scope, climate and river runoff

According to an agreement between China, Japan, ROK, and Russia (1994) based on the United Nation principles, the NOWPAP region includes marine, coastal and offshore basins at 32°-52°N and 121°-143°E (Fig. 1). That is the western part of the Yellow Sea called the Bohai Sea is technically outside of the NOWPAP region, and the data on such rivers as the Huaihe, the Yihe, the Huanhe, the

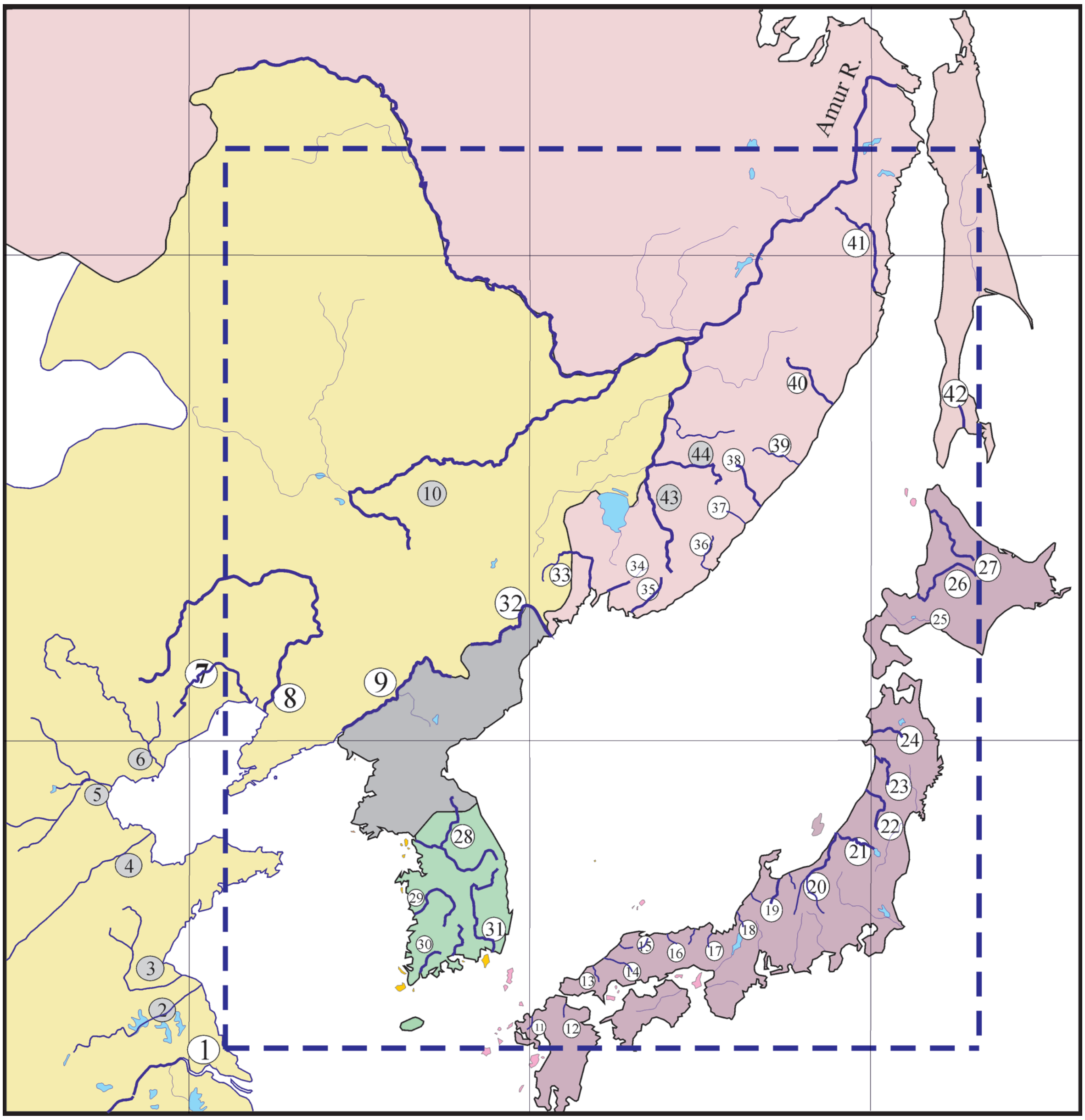


Figure 1. NOWPAP Region (within a dashed line) with the rivers keyed in the Table 1. Shadowed numbers mark the rivers indirectly influencing on the NOWPAP area

Haihe, and the Luanhe are not included in this overview. At the same time, these rivers were analyzed in the previous RDI ROs (2006, 2009) due to their obvious indirect influence on the marine environments within NOWPAP region. The rivers discussed in this Regional Overview with the data on watershed size and water discharge are listed in Table 1 with distinguishing of rivers indirectly related to the NOWPAP area. Major part of big rivers is depicted on Figure 1.

The terrestrial part of China occupies the lowland west coast of the Bohai Sea and the Yellow Sea. Two large hilly peninsulas, Liaodong and Shandong, with an average elevation of 500 m, are located between the Bohai Sea and the Yellow Sea. The major relief of Jiangsu province, Shandong province and Liaoning province are hilly and plain regions, while mountainous regions cover a big proportion in other two provinces - Heilongjiang and Jilin. The major river basins of the region include the Songhua , Haihe , Yellow, Huaihe, Liaohe, Yaluhe and Yangtze rivers, with overall annual runoff varied from 1,193 km^3 (2002) to 1,117 km^3 (2005), that is relatively stable. The Yangtze River provides 80-85% of this water discharge. When the Yangtze and Songhua rivers are excluded, annual river input is about 177 km3. All rivers have peak runoff in summer and minimum discharge in winter.

Japan is rather mountainous, with elevations up to 3,000 m in central Honshu Island, up to 2,300m in Hokkaido Island and up to 1,800 m in the south of Kyushu Island. Despite relatively high population and intensive agriculture, forests and wildlife parks cover 71.4% and 13.9%, respectively of the prefectures facing the NOWPAP marine region. Eight large rivers exist among the numerous rivers on the northwest coast of Japan: Teshio and Ishikari at the Hokkaido Is., Yoneshiro, Omono, Mogami, Agano, Shinano and Jintsu at the Honsyu Is. These rivers had a total annual (2016) runoff about 83 km^3, and an annual runoff of 17 rivers accounted in Table 1 and Fig. 1 reached up 101 km^3, whereas a total runoff of all 35 first class rivers at the west coast Japanese reached up to 124 km^3. The rivers located in the prefectures west of Toyama exhibit relatively small flow rates compare with situated eastward.

The southern part of the Korean peninsula is mostly hilly and mountainous terrain with average elevation about 400-600 m. The principal range is the T'aebaek-sanmaek that extends in a generally north-south direction parallel to the east coast. The country's highest peak is located on the island of Cheju, is Halla-san (1,950 m). The next highest peak Chiri-san (1,915 m) is situated at the south part of Korean peninsula between Busan and Kwangju. Mixed deciduous and coniferous forests cover about three-quarters of the peninsula. Less than one-fifth of the total area is occupied by plains and these are concentrated in the west along the coast; the coastal plains in the east and south are very narrow. Apart from the east coast, South Korea has a highly rugged coastline characterized by high tidal ranges, especially at the west coast where tides reach up 5 m and well developed tidal mudflats take place. The main five rivers include: the Han River, Guem River, Yongsan River, Somjin River and Nakdong River with total annual runoff about 40 km^3 (Table 1) and significant inter-annual variability.

The Russian territory of NOWPAP includes Primorskii Krai (Primorye), parts of southeastern Khabarovskii Krai, and south parts of Sakhalin Island. About 80% of Primorskii Krai and the adjoining part of Khabarovskii Krai are occupied by the mountains of the Sikhote Alin mountain system. An average elevation is 600 meters, with the highest peaks reaching 1,855 meters. Southern Sakhalin Island has low mountains and hills. Almost 80% of the territory is covered by forest. The main rivers directly inputting to the NOWPAP sea area are the Tumannaya (Tumen), the Razdolnaya (Suifun), Partizanskaya (Suchan), the Samarga, the Koppi, the Botchi, and the Tumnin with a total multiyear annual runoff about 40 km^3. There is notable inter-annual variability of river runoff, for example, in 2015-2016 regional annual runoff was 1.5-1.7 more than multiyear average. The main river of south part of Sakhalin Is. are the Poronai R. and Susuya R. with average runoff 2.5 and 0.9 km^3 respectively, but 77% of all river runoff is provided by small streams, and it allows us to assess the average runoff from Sakhalin Is. as 9.66 km^3, and total annual input of all rivers in the Russian portion of the NOWPAP as about 50 km^3 with 30-40% inter-annual variations. Besides rivers directly inputting to the NOWPAP sea area, there are big rivers at the Primorye, namely Ussury (Wissuli) and Ussurka Rivers indirectly influencing on the NOWPAP sea area through the Amur River. Averaged runoff of these rivers are 7.5 and 8.9 km^3 respectively (Table 1).

Monsoon is a key climatic feature of the entire NOWPAP region, accompanied by the strong seasonal variation, but there are obvious climatic differences due to more than 2,000 km south to north stretch. The climate of Jiangsu Province and Shandong Province in China belongs to the warm temperate zone with moist continental monsoon features. In summer these provinces are often hit by typhoons. Annual precipitation in Jiangsu Province is about 1,000 mm, while Shandong Province gets

Table 1. Averaged characteristics of the major rivers of the NOWPAP region

N*	River	Province, region, sub-region,	Watershed size, 10^3 км^2	Discharge, m^3/s	Runoff, km3 /y
	China				
1	**Yangtze****	Jiangsu	1,809	32,788	**1034**
2	Huaihe	Jiangsu/Shandong	269	1972	62.2
4	Yellow	Shandong	752	2096	66.1
5	Haihe	Hebei/Tianjin	264	723	22.8
7	**Dalinghe**	Liaoning	14.4	13.0	**0.41**
8	**Liaohe-Daliaohe**	Liaoning	229	469	**14.8**
9	**Yalu**	Liaoning/Jilin	61.9	1218	**38.4**
10	Songhua	Jilin/Heilongjiang	557	2435	76.2
	Japan				
27	**Teshio**	Hokkaido	5.9	197.7	**6,24**
26	**Ishikari River**	Hokkaido	14.3	457.9	**14,4**
25	**Shiribetsu River**	Hokkaido	1.6	58.8	**1,85**
28	**Iwaki River**	Touhoku	2.5	65.4	**2,91**
24	**Yoneshiro River**	Touhoku	4.1	223.6	**7,05**
23	**Omono River**	Touhoku	4.7	314.9	**9,93**
22	**Mogami River**	Touhoku	7.0	407.7	**12,9**
21	**Agano River**	Hokuriku (N)	7.7	474.6	**15,0**
20	**Shinano River**	Hokuriku (N)	11.9	404.1	**12,7**
18	**Seki River**	Hokuriku (N)	1.1	41.6	**1,73**
19	**Jintsu River**	Hokuriku (S)	2.7	161.0	**5,08**
16	**Oyabe River**	Hokuriku (S)	1.9	55.8	**3,39**
17	**Yura River**	Kiriki	1.9	46.9	**1,48**
15	**Hii River**	Chugoku/Kyusyu	2.1	39.3	**1,24**
14	**Gono River**	Chugoku/Kyusyu	3.9	114.7	**3,76**
12	**Onga River**	Chugoku/Kyusyu	1.0	22,8	**0,72**
11	**Matsuura River**	Chugoku/Kyusyu	0.4	8,8	**0,28**
	Korea				
28	**Han River**	Gyeonggi	26.0 (35.7)1	613	**19.3**
29	**Geum River**	Chungnam, Jeon-buk	9.8	132	**4.2**
30	**Youngsan River**	Jeonnam	3.5	48,3	**1.52**
	Seomjin River	Jeonnam	4.9	98,6	**3.11**
31	**Nakdong River**	Gyeongbuk	23.8	334,9	**10.6**
	Russia				
32	**Tumen**	Jilin/Heilongjiang	33.2	215	**6.78**
	Tsukanovka etc.[2]	Primorye	1.5	25.4	**0.80**

N*	River	Province, region, sub-region,	Watershed size, 10^3 км^2	Discharge, m^3/s	Runoff, km3 /y
33	**Razdolnaya**	Primorye	16.8	74,6	**2.35**
34	**Artyomovka etc.[3]**	Primorye	2.6	16.6	**0.52**
35	**Partizanskaya**	Primorye	4.1	36,9	**1.16**
	Margaritovka etc.[4]	Primorye	5.7	66.9	**2.10**
36	**Avvakumovka**	Primorye	3.2	16	**0.50**
	Zerkalnaya	Primorye	1.9	17.5	**0.55**
37	**Rudnaya**	Primorye	1.1	14.5	**0.46**
38	**Serebryanka etc.[5]**	Primorye	8.6	94.2	**2.99**
39	**Maksimovka**	Primorye	2.2	32.1	**1.02**
40	**Samarga etc.[6]**	Primorye	12.1	155.9	**4.95**
41	**Tumnin**	Khabarovsk	22.4	252	**8.00**
42	**Rivers of southern Sakhalin Is./Susuya R.**	Sakhalin-S	23.2/0.8	306.2/28.5	**9.66/0.9**
43	Ussury (Wissuli)	Primorye	26.2	237	7.47
44	Ussurka	Primorye	29,6	283	8,93

* - Number of river on Figure 1; ** - Rivers directly related to the NOWPAP region are marked by **BOLD**; 1 – Including watershed in PDRK; 2 – Including Amba, Barabash and Narva rivers; 3 – Including the Shkotovka and Suhodol Rivers; 4 – Including Kievka,Chernaya and Milogradovka Rrthe vers; 5 – Including Gigit, Kema, and Amgu Rivers; 6 – Including Svetlaya, Peya, Kabanya and Edinka Rivers

550~950 mm. The northern three Provinces (Liaoning, Jilin, Heilongjiang) belong to the temperate continental monsoon climate zone with rather cold winter and hot, rainy summer. Winter lasts longer than in other Chinese provinces. Annual precipitation varies from 400 to 970 mm.

The climate of the Japanese northwest coast situated within NOWPAP area is characterized by heavy snowfall brought on by humid northwest winter monsoons. Average annual precipitation (1981-2010) increases from 1,106 mm at Sapporo (Hokkaido) to 2,300 mm at Toyama (middle Honshu) and then decreases to 1,612 mm at Fukuoka. In summer, the wind blows mainly from the southeast giving rise to hot and humid weather. Another unique characteristic of Japan's climate is that it has two long spells of rainy seasons, one is early summer when the southeast monsoon begins to blow, and the other in autumn when the wind ceases. From summer to autumn, tropical cyclones generated in the Pacific Ocean develop into typhoons and sometimes hit Japan, causing serious storm and flood damage.

The climate in Korea is similar to the moderate climate of the Japanese and Chinese coasts. Rainfall is concentrated in the summer months of June through September. The river runoff is maximum in summer also. The southern coast gets late summer typhoons that bring strong winds and heavy rains. Average annual precipitation in Seoul is 1,370 millimeters and in Busan - 1,470 mm.

Cold dry winters and moderate warm humid summers are typical for the Russian mainland part of NOWPAP region. Annual precipitation decreases from about 800 mm at the sea coast to 650 mm near the Lake Khanka Lake 200 km away the sea. 80-95% of annual precipitation comes in the April to October period, and major part of river runoff takes place in summer. Climate of southern of Sakhalin Is. is milder with annual precipitation 750-990 mm for the different place. It is close to mainland areas, but distribution through the year is more even, and distinct snow accumulation is observed. The bi-modal distribution of Sakhalin's river discharge takes place due to this reason.

3. Social and economic situation in 2006-2016

Social and economic development in the NOWPAP countries in 2006-2016 remains to grow, though big difference in the status and dynamic of changes continues to observe in the region.

China. Northeastern provinces (Jiangsu, Shandong, Liaoning, Jilin and Heilongjiang) demonstrated sustainable growth of GDP (gross domestic products) in 2006-2016 which was even faster than in 2001-2006, and only last 2-3 years GDP growth has slowdown to 3.5% per year compare with 12-16% in 2008-2011 (Fig. 2). Population of Jiangsu, Shandong, Liaoning, Jilin and Heilongjiang provinces for the last 16 years grew up for the 6% only from 271 to 288 mln persons (Fig. 2). It is clearly reflect the high efficiency of economy in this regions of China and real significant increase of GDP per capita: from approximately 1500 USD in 2001 to 9600 USD. Taking into account necessity to adjust GDP per capita to the purchasing power parity (ppp) the current GDP per capita ppp in China could be assessed as 15000 USD

The difference between provinces in terms of GDP and population dynamic during 2001-2016 period was not significant (Fig. 3). It also marks if not equal, but similar distribution of GDP per capita within northeastern provinces of China.

The notable increase of the areas used for agriculture purpose during the last 8 years is a remarkable feature of the land use in the northeastern Chinese provinces (Fig. 4). It is potentially important peculiarity for the river runoff of nutrients and some other chemical substances, because agriculture

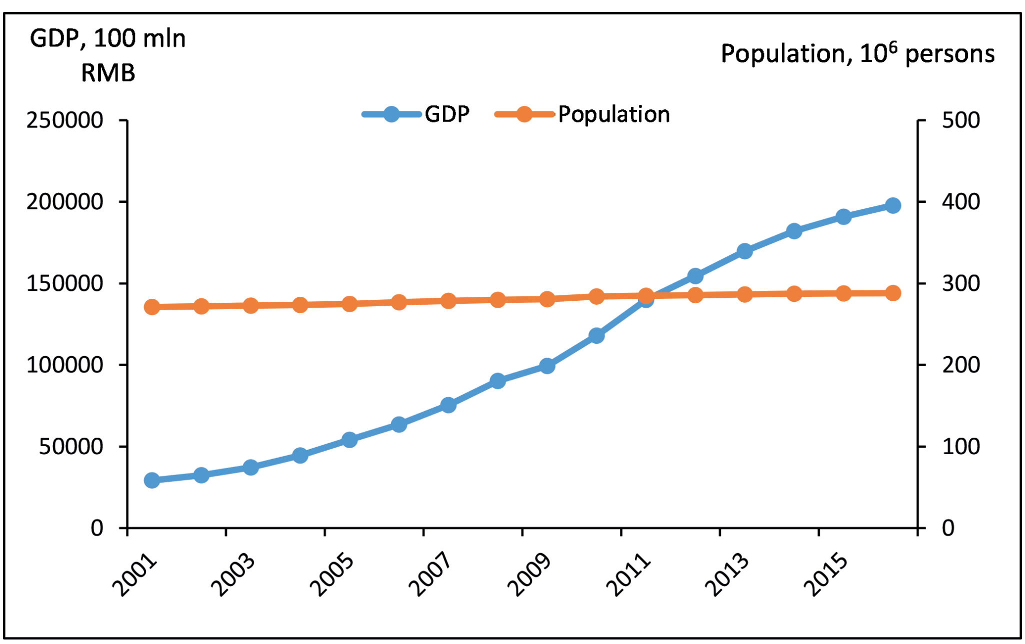


Figure 2. Dynamic of GDP and population of northeastern Chinese provinces directly related to the NOWPAP region (Source: China Statistical Yearbooks)

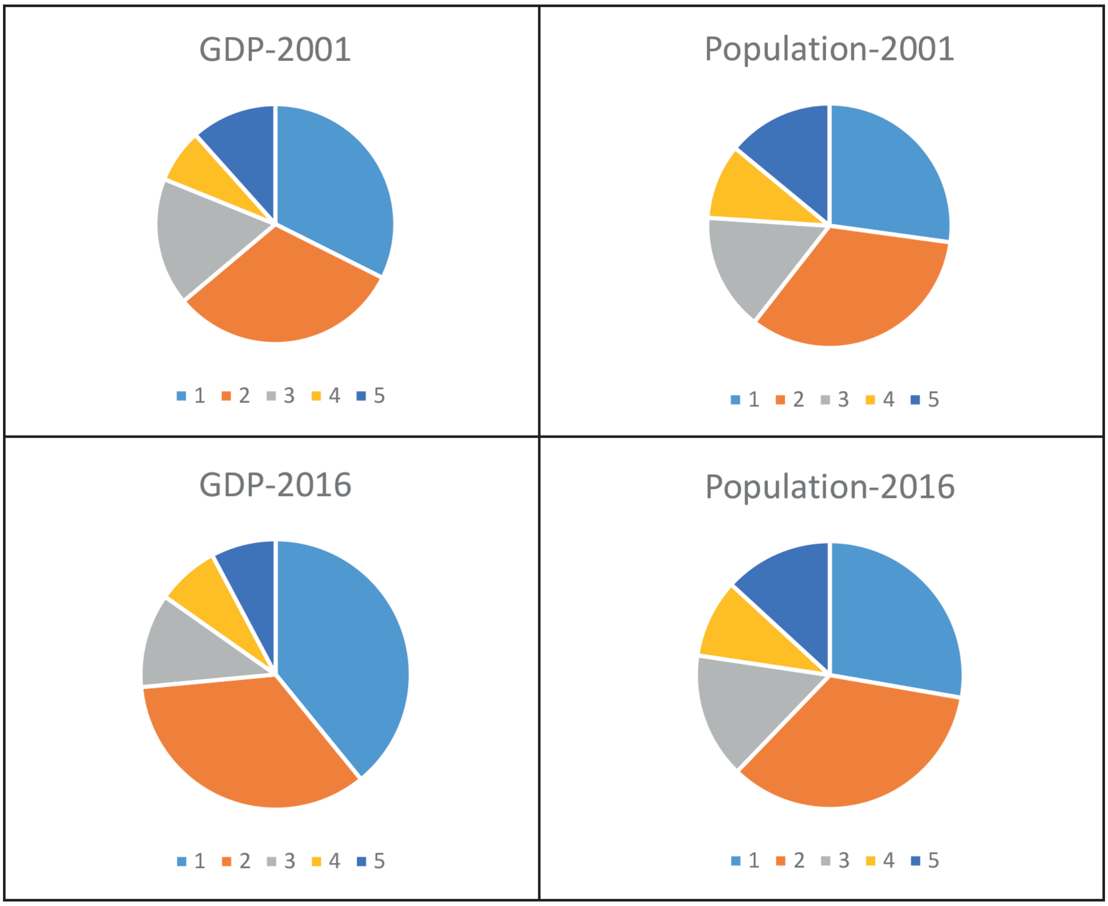
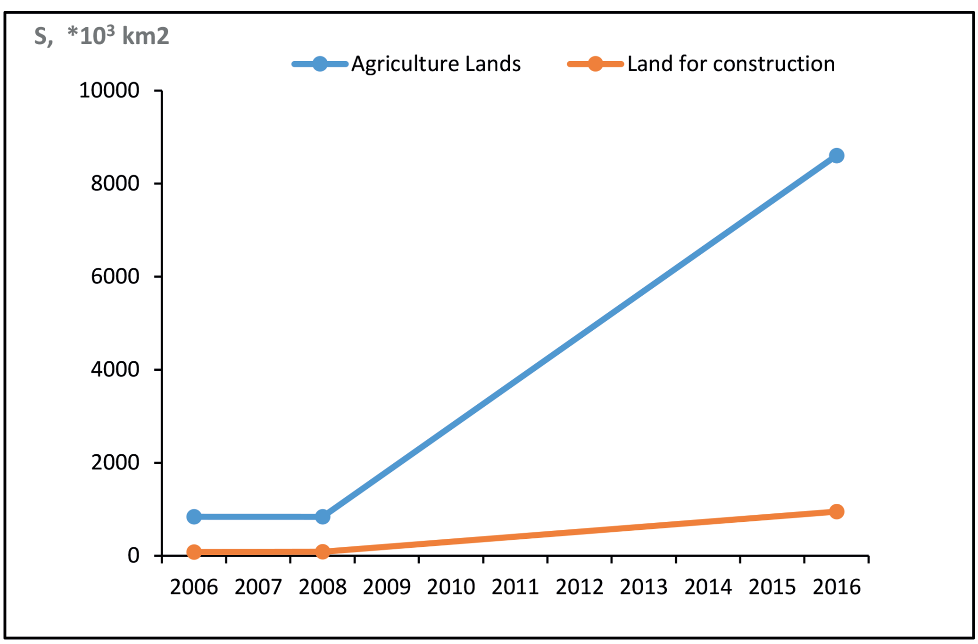


Figure 3. Quota of different northeastern Chinese provinces in GDP and population pools in 2001 and 2016; 1- Jiangsu, 2 – Shandong, 3 – Liaoning, 4 – Jilin, 5 – Heilongjiang

land use is accompanied by applying of fertilizers and pesticides. It could lead to the transfer of these substances to the streams and rivers.

The structure of water use in the northeastern Chinese provinces is characterized by strong prevalence of water use for agriculture (Fig. 5): 55% in Jiangsu province, and up to 68-90% in Shan-

Figure 4. The dynamic of areas involved in the agriculture and construction land use in the northeastern Chinese provinces during last decade



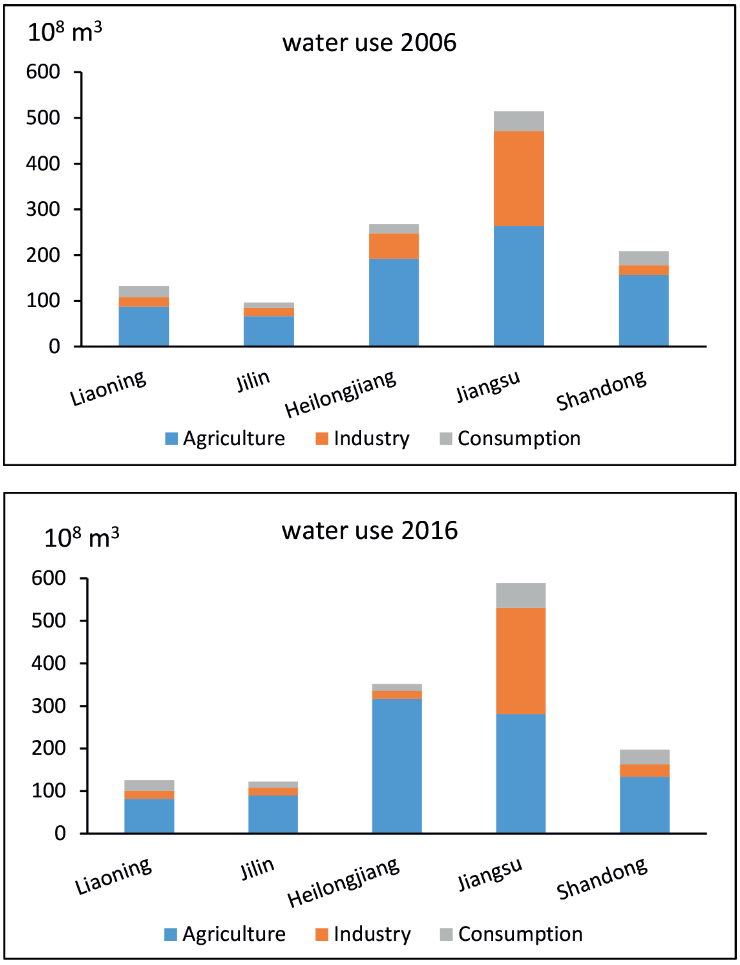


Figure 5. The structure of water use in five northeastern Chinese provinces related to the NOWPAP region in 2006 and 2016 (Source: China Statistical Yearbooks 2006-2017).

dong and Heilongjiang provinces. Quota of waters used for the industry (production) are also variable: from 5-10% in Shandong and Heilongjiang provinces to 45% in Jiangsu province. Waters used for consumption present the minor part in the structure of water usage (Fig. 5), and is proportional to the populations. The regional features of the structure of water use were rather stable during the last decade (Fig. 5).

Dynamic of water use in the northeastern Chinese provinces during the last decade is characterized by the stable level 32.5-33.5 km^3/y of water used for industry (production), slight increase of water consumption for municipal use, and notable growth of water for agriculture usage especially for the period 2006-2012 with some stabilization after that (Fig. 6).

The annual volume of wastewaters generated and released by industrial activities and due to consumption of population were reported separately for each province by the China Statistical Yearbooks until 2010. Moreover the

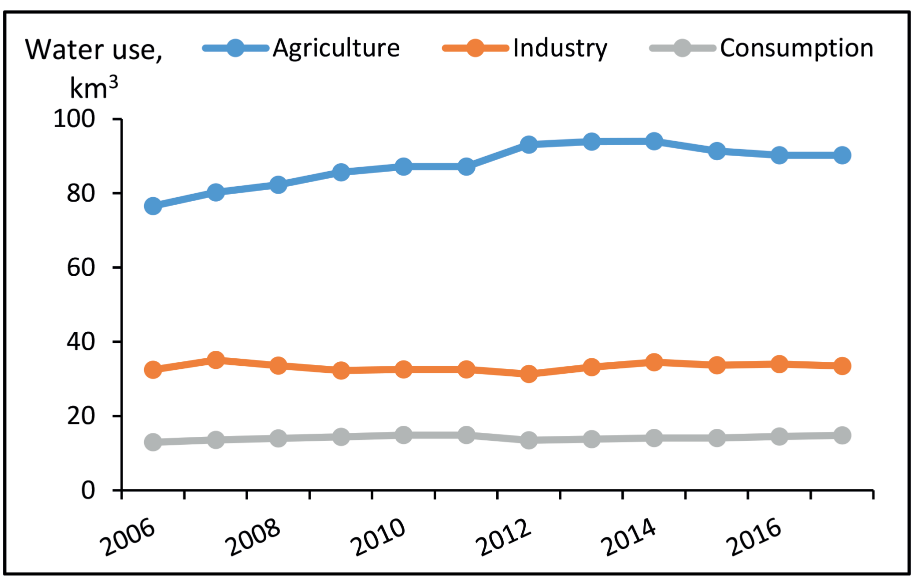


Figure 6. Dynamic of annual water use for different purposes in the northeastern Chinese provinces (Heilongjiang, Jilin, Liaoning, Shandong, Jiangsu) during the last decade (Source: China Statistical Yearbooks 2006-2017)

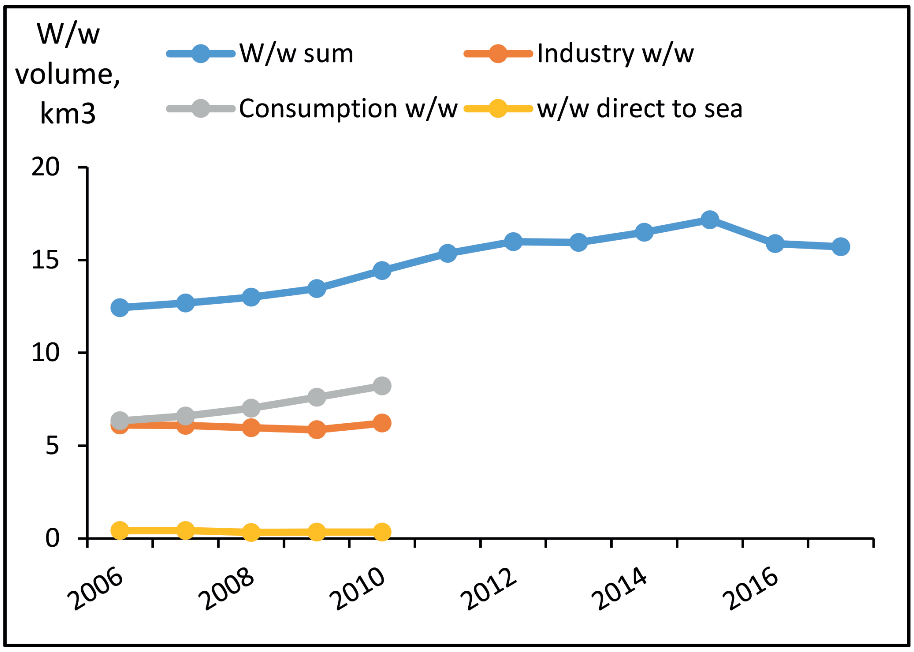


Figure 7. Dynamic of wastewaters (w/w) discharge from industrial sources, generated at the consumption, and their sum for 5 northeastern Chinese provinces, and wastewaters discharged directly to the sea from the Jiangsu, Shandong and Liaoning provinces (Source: China Statistical Yearbooks 2006-2017)

volume of wastewaters directly discharged to the sea was reported. Since 2011 the sum of these types of wastewaters was reported only (Fig. 7). Notable increase trend for wastewaters from 12.4 to 17.2 km^3 is observed in the last decade. According to the existing available data for 2006-2010 period one can suppose that increase trend is provided by upsurge of wastewaters from consumption of water by population (Fig. 7).

The amount of wastewaters generated in the different northeastern Chinese provinces (Fig. 8) are related to the volume of water use (Fig. 5) with the structure of wastewaters controlled by the economic specialization of the province.

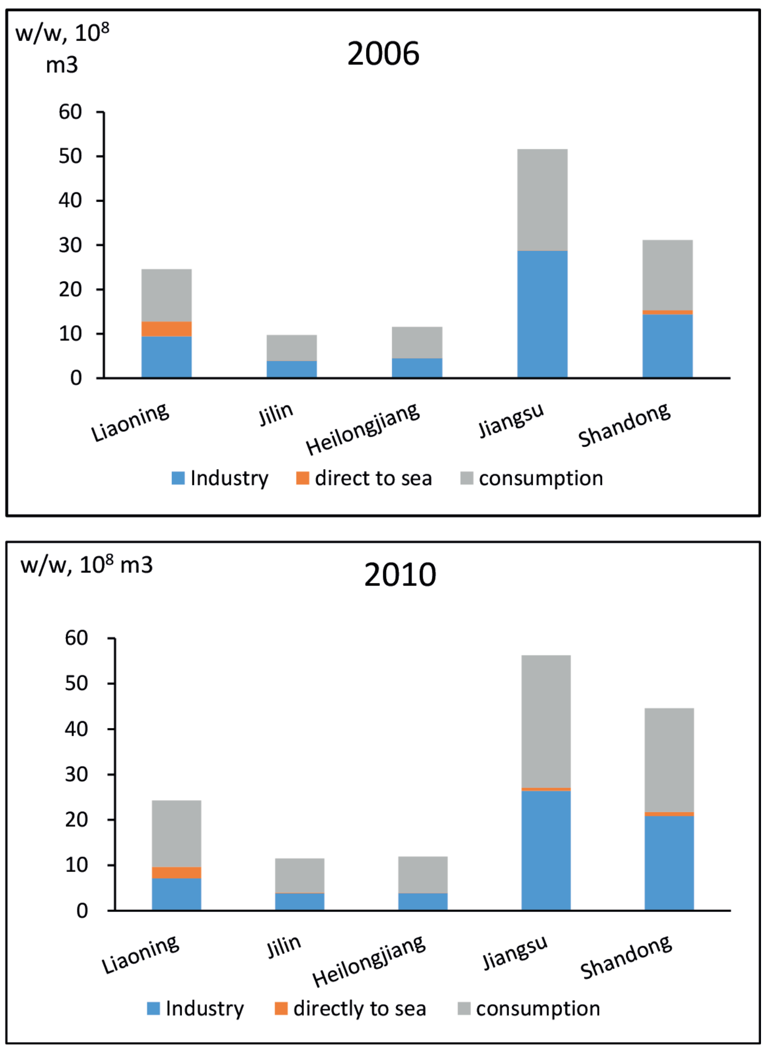


Figure 8. Genesis of wastewaters generated in northeastern Chinese provinces in 2006 and 2010 (Source: China Statistical Yearbooks, 2007, 2011).

Abovementioned features of water use in China should be taken into account at the discussion of water balance in terms of water use and wastewater generation and release, since the fate of the water used for different purpose is also different. Large part of water used for agriculture is lost due to evapotranspiration, and we believe that this is a major reason of such a big difference between volumes of water use and wastewater release in northeastern Chinese provinces.

Japan. The most striking social event that occurred during the last decade in Japan is decline in nation's total population. Japan's total population in 2017 was 126.71 million down by 227.000 from the year before. This ranked eleventh in the world and made up 1.7 % of the world total. Japan's population density measured 340.8 persons per square kilometers in 2015, ranking eleventh among countries and areas with a population of 10 million or more. Major part of population in Japan live in the cities. Percentage of rural population in the prefectures facing NOWPAP sea area do not exceed 21%. Overall density of population in these prefectures is about 280 persons/km^2, that is notably less than in the major Japanese metropolitan areas (Kanto, Chukyo, and Kinki) with population density 1,288-2,771 person/km^2.

Japan's industrial structure has undergone a significant transformation during last 50 years. In 1970, the primary industry accounted for 19.3 % of employed persons, the industry for 34.1%, and the tertiary industry for 46.6 %. In 2015, the corresponding shares of these three sectors were 4.0 %, 25.0 % and 71.0 %, respectively. Comparing the share of employed persons between the year of 2005 and 2015, the share of primary industry a little decreased and that of tertiary industry a little increased during the decade.

As for GDP by the type of economic activity in 1970, the primary, secondary and tertiary industries accounted for 5.9 %, 43.1 % and 50.9 %, respectively. In 2015, these figures for the primary, secondary and tertiary industries were 1.1 %, 26.5 % and 72.4 %, respectively. Comparing the share of GDP between the year of 2005 and 2015, the share of primary industry, secondary industry and tertiary industry showed a little change during the decade.

Over the course of Japan's economic growth, its agricultural, forestry and fishing industries employ fewer and fewer workers every year, and their GDP share has also dropped. The number of workers decreased from 13.40 million in 1960 (30.2 % of the total workforce) to 2.23 million in 2016 (3.4 %), and the GDP share of the industries fell from 12.8 % in 1960 to 1.2 % in 2016. Japan's cultivated agricultural acreage shrank year after year from 6.09 million hectares in 1961 to 4.44 million hectares in 2017. The most common cause for the decrease was degraded farmland due to decreasing numbers and aging of farmers. Japan's forest land area is 25.08 million hectares and amounts to approximately 70% of the entire surface area of the country (2012). Of this, natural forests account for 54%, while planted forests, most of which are conifer plantations, make up 41%. Japan's fishery output has been on the decline since 1989. Its 2017 fishery production totaled 4.30 million tons. Of this, marine fishery and aquaculture production amounted to 4.24 million tons. Although the aging of fishery workers progresses, fisheries have been gaining attention as a place for employment for younger generation. Accordingly, support for new fishery workers is recently being provided.

The construction industry, accounting for about 10 percent of both GDP and all employed persons, is one of the core industries in Japan. Construction investment at current prices had been on a declining trend after reaching a peak of 84 trillion yen in a fiscal year 1992, and fell to half of this peak (42 trillion yen) in a fiscal year 2010. Since then, they have been on a recovery trend partly due to such factors as the recovery from the Great East Japan Earthquake. The manufacturing sector in 2016 had 217,601 establishments (with four or more persons engaged). In 2016, there were 7.50

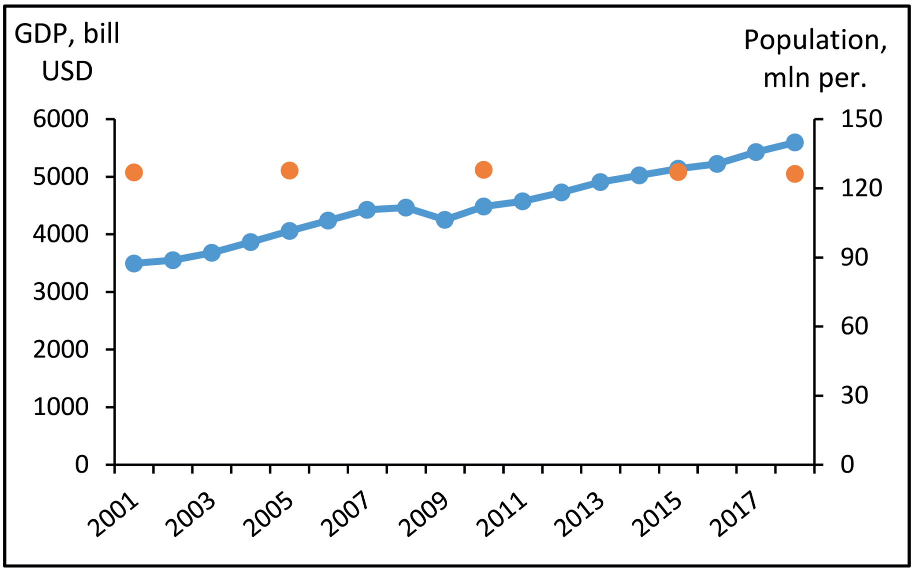


Figure 9. Dynamics of GDP and population of Japan for 2001-2017 (Source: Statistic Handbook of JAPAN 2018, Statistics Bureau, Ministry of Internal Affairs and Communication (2018))

million persons engaged in manufacturing, and by industry, "food" had the most, with 1.11 million persons engaged (component ration of 14.8 percent), followed by "transportation equipment" with 1.04 million persons engaged (13.9 percent) and "fabricated metal products" with 0.58 million person engaged (7.8 percent).

A total volume of water use nationwide in Japan varies around 81-85 km^3 per year, (Fig. 10), and 2/3 of this amount is water used for agriculture (irrigation, rice production etc.). The wastewaters generated after agriculture are not accounted separately in Japan with exception of sewages from

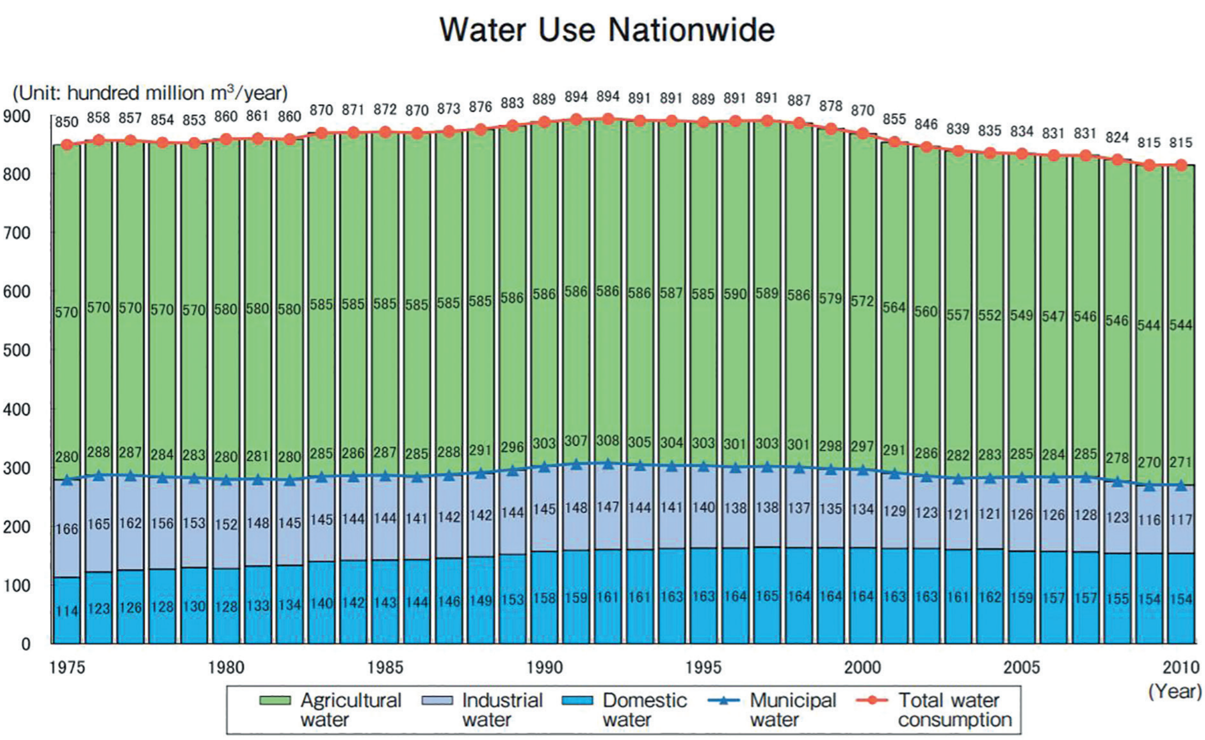


Figure 10. Structure of water use in Japan during 1975-2010 (Source: http://www.jwwa.or.jp)

animal farms. Water used for industrial purpose was around 20% of total 30-40 years ago, but during last decade the quota of water used for industry declined down to 14% and continue to be at this level. Wastewater effluents from industry are treated, strongly regulated in terms of concentration of contaminants and accounted, though these data are not freely available. The quota of water used for domestic purpose increased from 11.4 km^3/y in 1975 to 16.4-16.5 km^3/y in 90th and slightly decreased to 15.1 km^3/y in 2015 (Fig. 10, http://www.jwwa.or.jp), though quota of domestically used waters continue to be at the same level 18% of the total water consumption. Domestic waters in Japan are almost totally treated (e.g. 92.7% in 2012) and cleaning standards are high enough (http:// www.gcus.jp/wp-content).

Korea. Economy of the Republic of Korea (ROK) continued to grow sustainably during the last decade as well as in the decade before (Fig. 11). The growth rate varied from 2.1 to 3.3% during the last decade with exception of crisis of 2008-2009 when growth of GDP dropped down to 0.7%. Nevertheless GDP per capita taking into account purchasing power parity increased from 17454 USD in 2001 to 39434 USD in 2017 that is more than twice.

The land use structure within ROK is rather stable with arable land 15.3%, permanent crops 2.2%, pastures 0.6%, that is agriculture land gives 18.1%. Major part of land (63.9%) is forested. The rest 18% of area are occupied by settlements, industrial, infrastructure and transport construction etc. Notable deficit of the land is obvious, and this circumstance explain many features and specific issues of the economic activities (projects) connected with river runoff and water ecosystems quality in Korea.

In 2002, total water withdrawal in Korea was an estimated 25.47 km^3, of which 15.8 km^3 (62 percent) for agriculture, 6.62 km^3 (26 percent) for domestic and 3.05 km^3 (12 percent) for industries. In 2016 total withdrawal increased up to 37.2 km^3, of which 15.2 km^3 for agriculture, 7.6 km^3 for domestic, and 2.3 km^3 for industrial usage (www.kosis.go.kr). The rest of withdrawal was used for the maintenance of water resources (dams, flushing etc.). The structure of water usage in Korea continues to be stable during last two decades though some trends of decreasing amount of water for agriculture and industrial use, and increasing amount of water for domestic use were observed (Fig. 12).

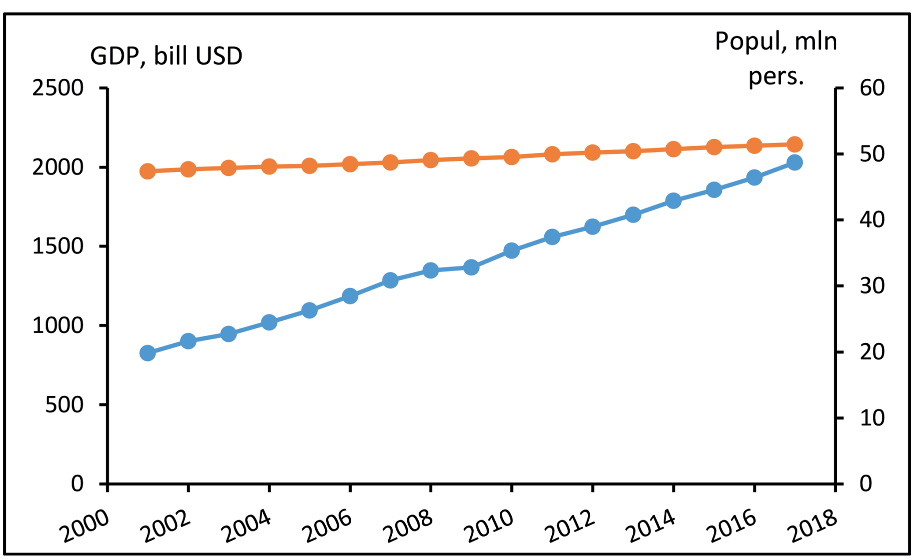


Figure 11. Dynamic of GDP and population of the Republic of Korea for 2001-2017 (Source: http:kosis.kr)

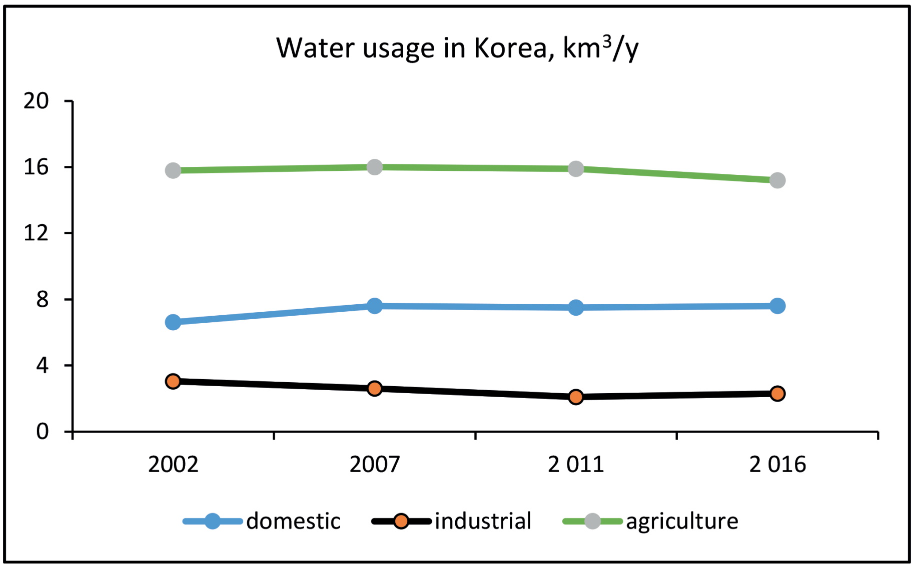


Figure 12. Structure of water usage in Korea in 2002-2016 (Source: www.kosis.go.kr)

One of the biggest issues relating to the coastal development in Korea was "Coastal reclamation" since the 1980s. For example, almost half of the coastal area (~2,500 km^2) in the Korean peninsula has disappeared by the large-scale reclamations over the past 40 years (Koh, 2001; Kim, 2010). Accordingly, Korea has faced into many environmental issues and problems including water pollution, algal blooming, and local fisheries collapse (Lee et al., 2018; Ryu et al., 2014), which in turn brought the paradigm shift in coastal policy from reclamation to sustainable management. The understanding of the historical reclamation project, including political, economic, sociological, and legal activities would be of critical background to link river and coastal inputs of contaminants.

The Four Major Rivers Project (FMRP) of Korea launched in the late 2000s has aimed to improve water quality and re-build up riverine public space. The main point of this project was to install about 16 weirs in the middle of major rivers and to dredge the bottom of rivers (massive volume of aggregate) on the scale to be able to ride cruise ships. The FMRP has attracted significant criticisms concerned for environmental problems, the impact on economic growth, and financial risks. The opposition from domestic and international NGOs, environmental groups, and professional scientific groups was quite strong but the government ignored and proceeded the project (Moon et al., 2010; Ko et al., 2011; Tienhaara, 2014; Song and Lynch, 2018). Artificial deformation of natural river and disruption of river flow by weirs and dams were critical points of environmental concerns.

Meantime, the Korean government has implemented the "Total Water Pollution Load Management System (TWPLMS)" to improve water quality in polluted rivers since 2004. And the TWPLMS has extended to the severely polluted river reaches outside of the four major rivers in 2012 upon the increasing problems relating to the FMRP.

River inputs of contaminants due to industrial developments have long been significant issue in the estuarine and coastal area of Korea over the past decades. Many coastal areas with the large industrial or/and residential complexes has long been suffered from environmental deterioration and ecosystem threats. Accordingly, the government has established the policy managing the inputs of contaminants to designated area, so called "Special Management Area (SMA)" which include five coastal regions; Masan Bay, Lake Sihwa, Busan coast, Ulsan coast, and Gwangyang Bay. These areas cover only 1.26% (1,263 km^2) of the national land area, but have 16.1% (8.2 million) of the total population.

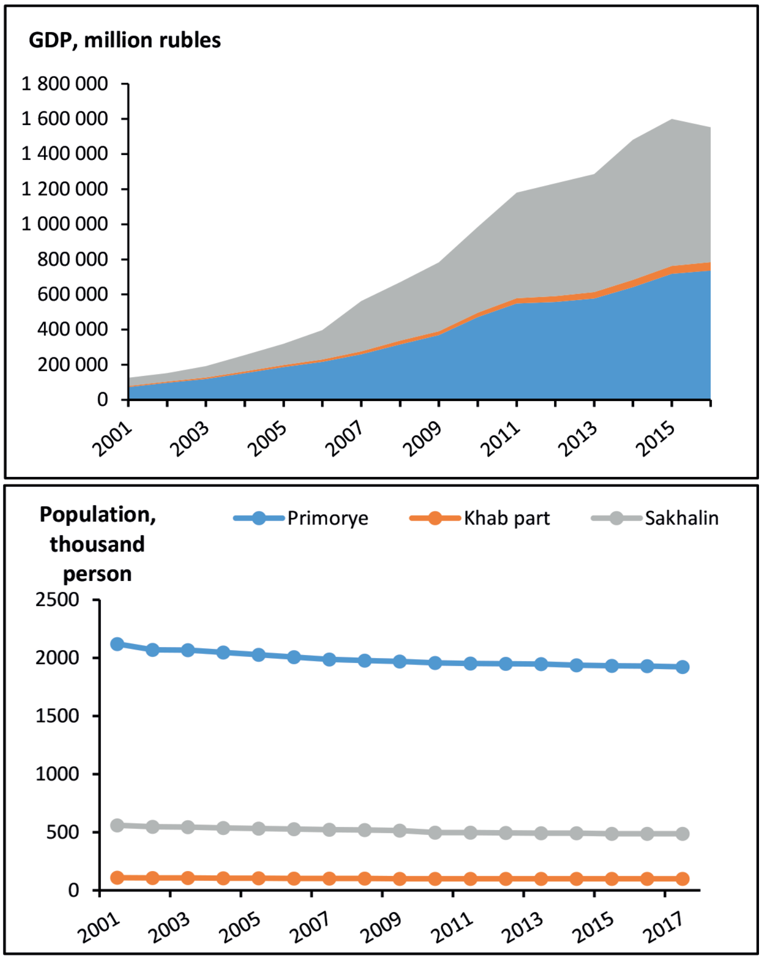


Figure 13. Dynamics of GDP (a) and population (b) in the Russian areas within NOWPAP region (Primorskii Krai, southeastern part of Khabarovskii Krai, and Sakhalinskaya Oblast)

Russia. Economic development of the Russian areas within NOWPAP region was quite stable during XXI century (Fig. 6a). Growth rate in rubles was very significant, especially in Sakhalinskaya Oblast due to oil and gas prospecting and producing at the shelf areas. Taking into account the twice devaluation of rubles again other currencies in 2014 the economic situation is not so good in the Russia as a whole and in the Russian Far East as well, and GDP per capita in USD continue to be the same in 2016 compare with 2008. Slight though stable depopulation is a next peculiarity of the socio-economic reality of the Russian areas within NOWPAP region (Fig. 13).

Economic development of the Primorskii Krai (Primorye) last decade was implemented through the growth of different industrial and logistic enterprises and agriculture as well. Latter was accompanied by the notable increase of fertilizers use (Fig. 14) that can be a potential source of the transformation of river runoff of nutrients.

Any agriculture activities, especially rice and vegetables crop growing, and some kind of industrial activity need plenty of water resources for the operation. Therefore, the data on the

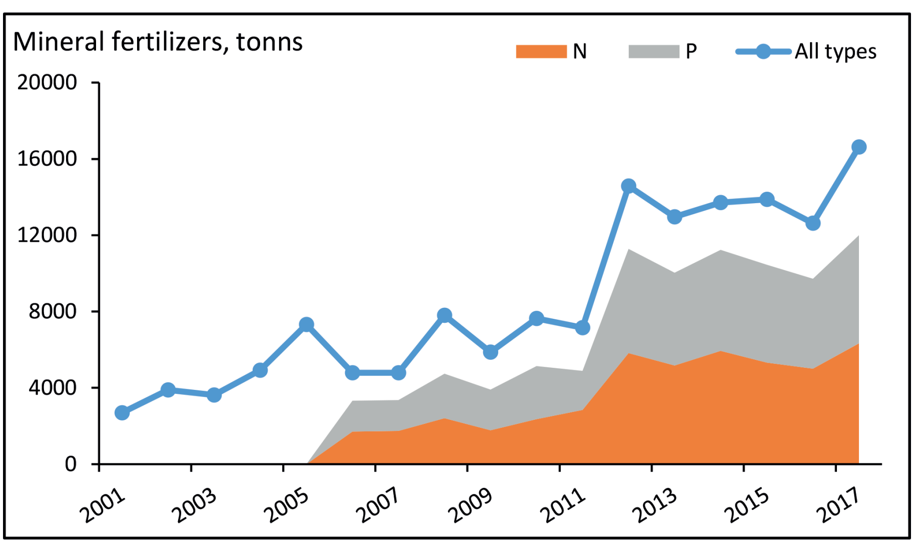


Figure 14. Mineral fertilizers usage in the agriculture of Primorskii Krai

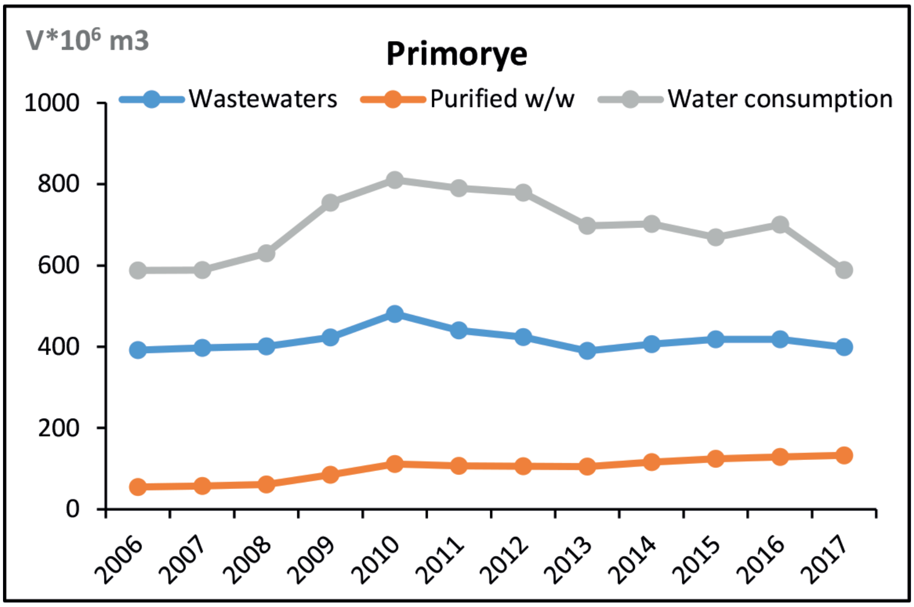


Figure 15. Dynamic of water consumption and wastewaters release (mln m^3) in Primorskii Krai in 2006-2017 (Source: Natural resources and environmental protection in Primorskii Krai: statistics review. Primorskstat, 2010, 2012, 2018).

water consumption can serve as a useful indicator of regional economic activity relevant to the assessment of the river water quality. Moreover, water consumption is directly connected with the volume of wastewaters, excluding the storm waters. Water consumption in Primorskii Krai during the last decade varied from 600 to 800 mln m^3 that is around 1% of the annual river runoff. 41-57% of this volume comes back to the rivers and the sea as wastewaters (Fig. 15). Only 16-17% of wastewaters were purified in Primory in 2006-2008, but this rate has grown up to 43-44% in 2015-2017 (Fig. 15).

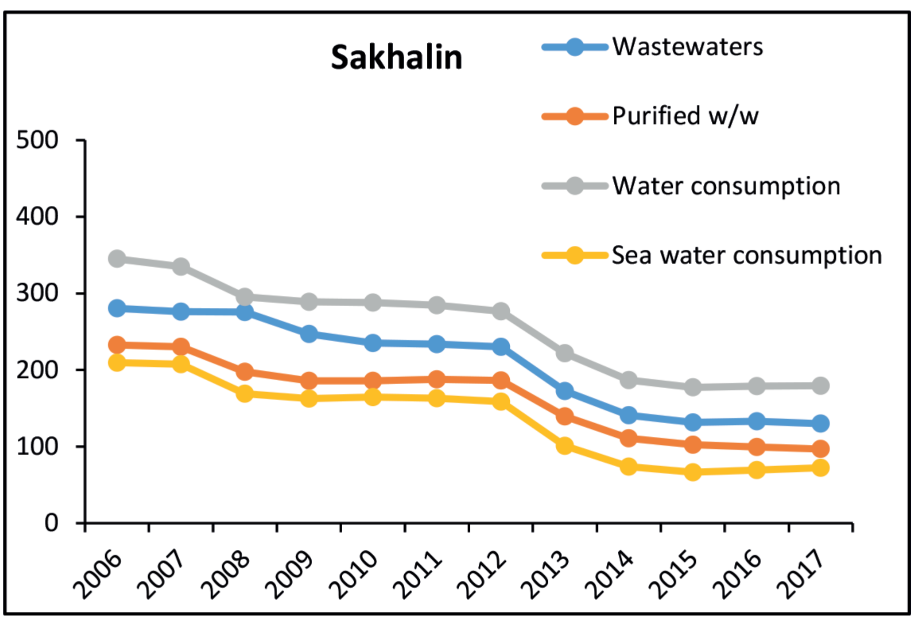


Figure 16. Dynamic of water consumption and wastewaters release (mln m^3) at Sakhalin Is. in 2006-2017 (Source: Reports on the ecological situation and environmental protection of Sakhalinskaya Oblast, http:// mpr.sakhalin.gov.ru)

Water consumption at Sakhalin Is. has different dynamic due to decrease of the sea water consumption (Fig. 16). Sea water is used in the industrial and power plants cooling systems, and the volume of this sea water dropped almost thrice during the last decade. The overall volume of water consumed has decreased accordingly, though consumption of fresh water also shows some stable decline from 135.4 mln m^3 in 2006 to 107.5 mln m^3 in 2017.

Another feature of water consumption at Sakhalin Is. is a rather high quota (75-83%) of purified wastewaters in the overall wastewaters released (Fig. 16). The volume of water consumption at Sakhalin Is. gives 1-2% in comparison with river runoff, that is similar to Primorye area.

4. National monitoring and assessment activities

China. China National Environmental Monitoring Center (CNEMC) is an organization directly affiliated to the Ministry of Ecology and Environment (MEE). CNEMC provides technical support, supervision and technical service for the environmental supervision management of MEE, plays a role as a network center, a technical center, an information center and a training center of national environmental monitoring. CNEMC is responsible for the management and guidance for the national monitoring system. There is an Environmental Statistic Division in the CNEMC with responsibility for the collecting, verifying and managing the environmental monitoring information and environmental statistic data. There are 2 different environmental monitoring networks in China: for the sea areas and for the surface (river) waters.

MEE set up in 2002 the Offshore Environmental Monitoring Center and six sub-stations of the National Offshore Marine Environmental Monitoring Network under CNEMC in Dalian, Tianjin, Qingdao, Xiamen, Shenzhen and Beihai. Offshore water quality and direct inputs of wastewaters to the sea are monitored by this Center.

Surface water Environmental Monitoring Network was set up in 1991. The network has been optimized in 2003, 2012, and 2015 for different environmental management needs. The number of sites has been increased now to 2050, compared to 759 in 2003. The number of assessment indexes have also increased from 9 to 21 since 2012. Monitoring of water quality of the rivers inputting to the sea was also carried out by this network.

For both networks monitoring is carried out by the comparison of data with environmental quality standards (EQS) for sea water (GB3097-1997) and for river fresh water (GB3838-2002). The different sets of EQS are established for the waters with different ecological status or types of usage. Four grades (classes) of water are established for sea areas, and five classes/grades– for the fresh waters.

For sea areas: Grade I includes fishery areas and natural protection areas of valuable or endangered species; Grade II includes sea breeding areas, bathing, sport and recreation areas; Grade III includes common industry water area, scenery and tour area; Grade IV includes harbors, sea mineral resource exploitation and work areas.

For surface waters: Grade I includes sources of drinking water and national nature protection areas; Grade II includes waters could be used as potable water source, and protection areas for the biological resources; Grade III includes aquaculture and swimming areas; Grade IV is related to general industrial water areas and entertainment water areas not directly touched by the body; and Grade V is related to the farmland water areas and water areas for general landscape requirement.

Table 2. Chinese environmental quality standards (mg/L) for sea waters of different classes/grades (GB3097-1997)

<table>
<tr><th>Parameter</th><th>Grade I</th><th>Grade II</th><th>Grade III</th><th>Grade IV</th></tr>
<tr><td>DO ></td><td>6</td><td>5</td><td>4</td><td>3</td></tr>
<tr><td>COD≤</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>BO≤</td><td>1</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>N-DIN</td><td>0.20</td><td>0.30</td><td>0.40</td><td>0.50</td></tr>
<tr><td>N-NH3</td><td colspan="4">0.020</td></tr>
<tr><td>DIP</td><td>0.015</td><td colspan="2">0.030</td><td>0.045</td></tr>
<tr><td>Hg≤</td><td>0.00005</td><td colspan="2">0.0002</td><td>0.0005</td></tr>
<tr><td>Cd≤</td><td>0.001</td><td>0.005</td><td colspan="2">0.010</td></tr>
<tr><td>Pb≤</td><td>0.001</td><td>0.005</td><td>0.010</td><td>0.050</td></tr>
<tr><td>Cr^{6+}≤</td><td>0.005</td><td>0.010</td><td>0.020</td><td>0.050</td></tr>
<tr><td>Total Cr≤</td><td>0.05</td><td>0.10</td><td>0.20</td><td>0.50</td></tr>
<tr><td>As≤</td><td>0.020</td><td>0.030</td><td colspan="2">0.050</td></tr>
<tr><td>Cu≤</td><td>0.005</td><td>0.010</td><td colspan="2">0.050</td></tr>
<tr><td>Zn≤</td><td>0.020</td><td>0.050</td><td>0.10</td><td>0.50</td></tr>
<tr><td>Se≤</td><td>0.010</td><td colspan="2">0.020</td><td>0.050</td></tr>
<tr><td>Ni≤</td><td>0.005</td><td>0.010</td><td>0.020</td><td>0.050</td></tr>
<tr><td>CN^- ≤</td><td colspan="2">0.005</td><td>0.10</td><td>0.20</td></tr>
<tr><td>S^{2-}≤</td><td>0.02</td><td>0.05</td><td>0.10</td><td>0.25</td></tr>
<tr><td>Volatile phenol≤</td><td colspan="2">0.005</td><td>0.010</td><td>0.050</td></tr>
<tr><td>oils≤</td><td colspan="2">0.05</td><td>0.30</td><td>0.50</td></tr>
<tr><td>BHC≤</td><td>0.001</td><td>0.002</td><td>0.003</td><td>0.005</td></tr>
<tr><td>DDT≤</td><td>0.00005</td><td colspan="3">0.0001</td></tr>
<tr><td>carbofos≤</td><td>0.0005</td><td colspan="3">0.001</td></tr>
<tr><td>Methyl Parathion</td><td>0.0005</td><td colspan="3">0.001</td></tr>
<tr><td>Benzo(a)pyrene (μg/L)</td><td colspan="4">0.0025</td></tr>
<tr><td>Anionic surfactant</td><td>0.03</td><td colspan="3">0.01</td></tr>
</table>

Sets of EQS for some parameters used in China for the monitoring of water quality in the sea areas and in the surface waters are presented in Table 2 and 3 respectively. Probability of occurrence, and a harmful degree are used for the ordering of contaminants. The main contaminants are the items which appear in more than 5% sites at the assessment of sea water quality. The main contaminants are the items which are the worst ones at the assessment of water quality for rivers and lakes/reservoirs.

Table 3. Chinese environmental quality standards (mg/L) for surface waters of different classes/grades (GB3838-2002)

Parameter	Grade I	Grade II	Grade III	Grade IV	Grade V
DO ≥	7.5	6	5	3	2
COD_{Mn}≤	2	4	6	10	15
COD_{Cr} ≤	15	15	20	30	40
BOD_5≤	3	3	4	6	10
N-N≤	0.15	0.5	1.0	1.5	2.0
TP≤	0.02 (0.01*)	0.1 (0.025*)	0.2 (0.05*)	0.3 (0.1*)	0.4 (0.2*)
TN ≤	0.2	0.5	1.0	1.5	2.0
Cu≤	0.01	1.0	1.0	1.0	1.0
Zn≤	0.05	1.0	1.0	2.0	2.0
≤	1.0	1.0	1.0	1.5	1.5
Se≤	0.01	0.01	0.01	0.02	0.02
As ≤	0.05	0.05	0.05	0.1	0.1
Hg≤	0.00005	0.00005	0.0001	0.001	0.001
Cd≤	0.001	0.005	0.005	0.005	0.01
Cr^{6+}≤	0.01	0.05	0.05	0.05	0.1
Pb ≤	0.01	0.01	0.05	0.05	0.1
CN^- ≤	0.005	0.05	0.2	0.2	0.2
Volatile phenol ≤	0.002	0.002	0.005	0.01	0.1
oils ≤	0.05	0.05	0.05	0.5	1.0
Anionic surfactant≤	0.2	0.2	0.2	0.3	0.3
S^{2-}≤	0.05	0.1	0.2	0.5	1.0

*- for lakes and reservoirs

A single factor assessment method is used for the surface water quality classification system, namely once any assessment indicator at a certain monitoring site exceeds standards, water quality is changed to the next grade/class.

The main Reports reflecting results of water quality monitoring in China are the follows:

(1) Reports on the State of the Environment in China have been published by SEPA since 1980'.

(2) Reports on the State of the Marine Environmental Quality in China have been published by SEPA since 1980'.

(3) Bulletin offshore Environmental Quality --- People's Republic of China has been published by SEPA since 2000.

(4) Annual Statistic Reports on Environment in China have been published by SEPA since 1990.

Concerning the sea environment protection, the main laws are "Law of Environmental Protection (1989)" and "Law of Marine Environmental Protection (1999)". There are some other related laws and regulations. The main national and international laws and regulations, related to the environment protection and approved by high authority in China, are listed in Table 4. Besides these laws there are more than 50 regulations (discharge and emission standards) approved at the ministerial level.

Table 4. Major Laws and Regulations Related to the Contaminants Inputs on Environment

Type	Name and Published Year of Document	Approved by
Law	Law of Fishery (1986)	People's representative Committee of China
	Law of Reservation for Wild Animals (1988)	
	Law of Water and Soil Conservation (1991)	
	Law of Mines Resources (1996)	
	Law of Marine Environmental Protection (1999)	
	Law of Promotion on Clean Production (2002)	
	Law of Environmental Influences Assessment (2003)	
	Law of Prevention on Environmental Pollution by Solid Wastes (2004)	
	Circular Economy Promotion Law of the People's Republic of China (2008)	
	Energy conservation law of the People's Republic of China (2009)	
	Law of Environmental Protection (2015)	
	Law of Water (2016)	
	Law of Maritime Environmental Protection (2017)	
	Law of Prevention and Control of Water Pollution (2017)	
Legislation	Managing Guidelines to Protecting on Propagation of Aquaculture Resources (1979)	State Council of China
	Managing Guidelines to Prevention Marine from Shipping (1983)	
	Managing Guidelines to Keep Contamination and Damage from Coastal Construction and Engineering (1990)	
	Managing Guidelines to Keep Contamination and Damage from Pollutants in Terrestrial Sources (1990)	
	Rules on Implementation of the Law of Prevention of Terrestrial Wild Animals (1992)	
	Technical Guidelines on Environmental Impacts Assessment (1993)	
	Rules on Implementation of the Law of Prevention of Water and Soil (1993)	
	Rules on Implementation of the Law of Prevention of Aquicolous Wild Animals (1993)	
	Guidelines on Natural Preservation Zones (1994)	
	Guidelines on Preservation of wild Plants (1996)	
	Management Ordinance of Environmental Protection on Projects (1998)	
	Detailed Rules on Implementation of the Law of Prevention of Water Pollution (2000)	
	Implementation Guidelines on Law of Forests (2000)	
	Regulation of the management of levy and usage of pollutant discharge fee (2003)	
	Regulation of the management of prevention and control of the maritime project pollution on marine environment (2006)	
	Regulations of the People's Republic of China on the Prevention and Control of Pollution Damage to the Marine Environment in Coastal Engineering Construction Projects	
	Regulation of the management of prevention and control of the coastal project pollution on marine environment (2007)	State Council of China
	Regulations on the Control of Marine Environmental Pollution by Ships (2009)	

Besides the routine collecting of data on the water quality of river and coastal environment, **China** implements monitoring activity in accordance with five years consequent plans. Each of them has distinct goals and aims.

For example, the 11th – five years (2006-2011) were concentrated on the promoting of the sustainable development of the coastal zone, enhancing the degree of executing the laws, implementing the system of total quantity control of lands pollution, researching about the environment capability of the coastal area, implementing the system of discharging license, and Enhancing the monitoring work in the coastal area, reducing the damage of red tide.

The 12th –five years (2012-2016) had a numerical target to diminish the amount of COD and ammonia discharged to the sea, to decrease the percentage of surface waters observation with Grade V, and to increase the percentage of observations better than Grade III. Deepening prevention and control of water pollution of key river basins, and comprehensive prevention and control of marine environment pollution and ecological damages were also important goals for this period.

Strategic targets for the 13th –five years (2016-2020) include 10% decrease of COD and ammonia discharge, and reaching of > 70% correspondence of surface water observations to the water quality Grade III or better.

Monitoring network in China is being re-organized now in accordance with function-oriented zoning and administrative divisions, establishing a three-tier water management system including river basins, aquatic ecology control areas, and aquatic environment control units. Objective oriented management for water quality in river basins will be established, with control units as the physical basis, water quality of sections as the management objective and pollution discharge permit system as the core. The monitoring network for the water quality of control units will be improved by establishing a feedback mechanism between pollution discharge of control units and water quality of sections, in order to clearly identify the responsibilities of certain control units for water quality deterioration and strictly control pollutant discharge. China will fully implement the "river chief system". Pilot projects will be initiated in river basins such as the Yellow River and the Huaihe River where the ecological flow (water level) is scientifically measured in different periods as an important reference to water resource allocation. Comprehensively controlling the pollution in river basins, China will implement the Action Plan on Water Pollution Prevention and Control in Key River Basins.

Besides the efforts on the improvement of environmental quality of rivers/lakes, China will carry out the Plan for the Prevention and Control of Offshore Marine Pollution. Direct discharge of marine pollutants and coastal industrial parks will see stricter monitoring to prevent marine pollution caused by land-based oil spills in the coastal regions. China will control ballast water and pollutants discharged by international sailing ships. The distribution of sewage outlets to the sea will be examined and all illegal outlets will be removed by the end of 2017. Most rivers that flow into the sea in coastal provinces, are expected to reach Grade V or better water quality by 2020. Coastal aquaculture density will be strictly controlled to facilitate eco-friendly aquaculture, with measures of vigorously restocking aquatic organisms and promoting the development of artificial reefs and marine ranching. A national natural coastline (excluding island coastline) is expected to keep at a level no lower than 35%, with improvement and restoration of 1,000 km coastline by 2020. China will develop a group of marine nature reserves, special marine protected areas and aquatic germplasm conservation areas. China will also conduct projects of ecological protection on islands and reefs to strengthen rare marine species conservation.

Japan. Significant changes occurred during the last decade in the Japanese legislation related with environmental issues. The Water Circulation Basic Act was promulgated in Japan on April 2, 2014. Before the adoption of the Act, Japan did not have any comprehensive law on water. Several government agencies in Japan have jurisdiction over water. For example, the Ministry of Land, Infrastructure and Transportation (MLIT) has jurisdiction over rivers; the Ministry of Economy, Trade, and Industry has jurisdiction over water for industrial use; the Ministry of Agriculture, Forestry, and Fisheries has jurisdiction over water for agricultural use; and the Ministry of the Environment for water quality etc. There was previously no nation- or area-wide system responsible for managing water resources. Since, Japan has relatively high precipitation and plenty of water resources per square meter of its territory, compared to the global standard, establishment of the Basic Act is valuable for river water management which is closely related to river and direct inputs of materials.

"Water circulation," as referred to in the Act, means the cycle of water evaporation and of rain falling, running down over the ground surface, sinking into the ground, and reaching the sea. Rivers are the centers of the circulation. The Act recognizes that proper water circulation is important for the environment, people's daily life, and industrial production, and that water is valuable property of the nation. Therefore, maintaining proper water circulation is important and water circulation through rivers must be managed comprehensively.

According to the Act, the national government will establish a Water Circulation Basic Plan. National and local (prefectural) governments are to take measures to improve the ability of land to retain water by, for example, proper retention of forests and management of farm lands. The national and relevant local governments will coordinate to manage river systems that cross local boundaries.

The approval of the Fifth Basic Environment Plan in April 2018 is also new. The Fifth Basic Environment Plan reflects the changes in the international and national situations as demonstrated by the SDGs and the Paris Agreement. For their implementation, six priority strategies were set as a cross-cutting framework that accounts for interlinkages, and enables specific environmental measures to help address various economic and social challenges in an integrated manner. The second strategy "Improvement of value of national land as stock" includes the following issues closely related to river and direct input management:

- Resilient society including climate change adaptation
- Ecosystem-based disaster risk reduction (Eco-DRR)
- Forest maintenance and conservation including forest environmental tax
- Renewable energy/energy saving
- Marine litter issues including microplastics

The Basic Environment Plan also calls for innovation across all perspectives including those concerning socio-economic systems, lifestyles, as well as technologies through the implementation of the policy measures listed in the priority strategies. Furthermore, it aims for the creation of a "Regional Circular and Ecological Sphere (Regional CES)" that complements and supports regional resources by building broader networks, which is composed of natural connections (Connections among forests, the countryside, rivers and the sea) and, economic connections (composed of human resources, funds, and others) in partnership. Each region will demonstrate its strengths by utilizing its unique characteristics, thereby building a self-reliant and decentralized society where different resources are circulated within each region, leading to symbiosis and exchange with neighboring regions according to the unique characteristics of each region.

The Basic Act on Ocean Policy was adopted in 2007 with the purpose to stipulate the basic principles, to clarify the responsibilities of the State, the local governments, business operators and the citizens as well as to formulate the basic plan with regard to the oceans and other basic matters. The

Plan on Ocean Policy based on the Basic Act on Ocean Policy was updated most recently in 2018. It emphasized conservation of marine environment towards achievement of SDGs .

Overview of national policies and the laws relevant to the discharge of pollutants to rivers or directly to the marine environment in Japan is summarized in Table 5.

Table 5. Relevant Statutes Concerning the Discharge of Pollutants to Rivers or Directly to the Marine Environment in Japan

	Source	Category	Relevant Statute	Load Amount Estimation Data
Environment Basic Law				
Municipal wastewater	Public sewage		Water Pollution Control Law [1] Sewage Law	Administrative monitoring
	The night soil treatment plant		Water Pollution Control Law [1] Wastes Management and Public Cleansing Law [3]	
	Johkasou (Septic tank)		Water Pollution Control Law [1] Johkasou (Septic Tank) Law	Reported parameter/ unit data
Industrial wastewater	Specified facilities [2]		Water Pollution Control Law [1]	Written report parameter data Monitoring records
	Non-specific facilities			None data
Non-point source wastewater	Natural load	Agriculture	Environment Basic Law (monitoring of public water area)	Basic unit data
		Livestock industry		Land use data
		Natural runoff		Statistical data
	Urban load	Urban area		Land use data
		City activity		Basic unit data
Ocean Dumping	Municipal waste		London Convention [4]; Wastes Management and Public Cleansing Law [3]; Marine Pollution Prevention Law [5]; Public Water Body Reclamation Law	Water quality monitoring of dumping site
	Industrial waste			
	Dredged soil			
	Vessel waste	Oil, , and waste	Marine Pollution Prevention Law [5]	

1) The Water Pollution Control Law.

2) The place where specified facilities exist.

3) Waste Management and the Public Cleansing Law. The dumping of sewage sludge and night soil to the sea will be prohibited according to the 2003 revision. All of the continuing parts of dumping will be prohibited by 2007.

4) The 1996 Protocol of London Convention. (The principle of the prohibition of discharge to the sea and incineration on the sea), which will come into effect in 2005, and the amended Marine Pollution Prevention Law will be enforced till May 2007.

5) The Law Concerning the Prevention of Seawater Pollution and Sea Disaster (effluent control of oil, hazardous substance, and waste from ship, marine facility, and aircraft).

Water Quality Standards in Japan consist of three sets: a) standards for protection of human health; b) standards for protection of living organisms; and c) uniform national effluent standards.

The standards for protection of human health and for the conservation of living organisms are applied to public water areas (river, lake and sea). Human health standards are nationally uniform and contain 27 designated toxic substances for human such as mercury, arsenic, chlorinated organic compound etc. (Table 6).

The standards for the conservation of living organisms were designated in order to conserve the river, lake and sea areas as well as the fauna and flora closely related to the living of people. The EQS standard values for various water quality parameters for rivers, lakes, and coastal waters are presented in Tables 7, 8, 9,10,11, 12, respectively. In Japan, the index of organic pollution of the rivers is BOD, and the index of organic pollution of coastal waters is COD. The reason of this difference of the parameter is as follows. The residence time of river water in Japan is too short and rich in the undecomposed organics, so BOD is thought to be a good index for river water. On the other hand, the lake and coastal water is poor in the undecompsed organics, COD is thought to be a good index for these water rather than BOD.

The substances identified for precautionary monitoring are designated as "monitoring substances" for which guideline values are provided as indicators of adaptability of living condition for aquatic life for various types of water bodies, i.e. rivers, lakes and coastal areas. The regulatory status of these monitoring substances is that more data on their environmental effects needs to be accumulated before EQS are established for them; therefore their concentrations in the environment should be monitored.

The monitoring substances and their guideline values in rivers, lakes and coastal areas of Japan are presented in Table 7, 8, 9,10, 11,12. Moreover concentration 0.03 mg/L Zn in the unfiltered water is established as an environmental quality standard (EQS) for all types of fresh waters. For the coastal waters EQS for the Zn is established as 0.02 and 0.01 mg/L for

Table 6. Standard values (WQS, mg/L) of waters for protection of human health

Chemical	Standard	Chemical	Standard
Cd	< 0.003	CCl_4	< 0.002
Pb	< 0.01	1,2-dichloroethane	≦ 0.004
As	< 0.01	cis-1,2-dichloroethylene	< 0.04
MeHg	undetected	1,1-dichloroethylene	< 0.02
Hg	< 0.0005	1,1,1-trichloroethane	< 1
Cr^{6+}	< 0.05	1,1,2-trichloroethane	< 0.006
Totalcyanide	undetected	Trichloroethylene	≦ 0.01
PCB	undetected	Tetrachloroethylene	≦ 0.01
Dichloromethane	< 0.02	1,3-dichloropropene	≦ 0.002
Thiuram	≦ 0.006	Simazine	≦ 0.003
Thiobencarb	≦ 0.02	Benzene	≦ 0.01
Selenium	≦ 0.01	1,4-Dioxane	≦ 0.05
N-NO3	10	Fluoride	≦ 0.8
1,4-Dioxane	≦ 0.05	Boron	≦ 1

- Values are annual average for all, except the maximum value for total cyanide.
- 'Undetected' means the value should not exceed the limit of determination of the designated method.
- Fluoride and Boron are not applied to the ocean area.

Table 7. EQS for conservation of the living environment in Japanese rivers

Class	Item	Standard Value				
	Water Use	pH	BOD	SS	DO	Total Coliform
AA	Water supply class 1, conservation of natural environment	6.5-8.5	≤1 mg/L	≤25 mg/L	≥7.5 mg/L	≤50 MPN/100ml
A	Water supply class 2, fishery class 1, bathing	6.5-8.5	≤2 mg/L	≤25 mg/L	≥7.5 mg/L	≤1000 MPN/100ml
B	Water supply class 3, fishery class 2	6.5-8.5	≤3 mg/L	≤25 mg/L	≥5 mg/L	≤5000 MPN/100ml
C	Fishery class 3, industrial water class 1	6.5-8.5	≤5 mg/L	≤50 mg/L	≥5 mg/L	-
D	Industrial water class 2	6.0-8.5	≤8 mg/L	≤100 mg/L	≥2 mg/L	-
E	Industry water class 3 and conservation of environment	6.0-8.5	≤10 mg/L	No Floating garbage	≥2 mg/L	-

Notes : 1. BOD : Biochemical Oxygen Demand, SS : Suspended Solids, DO : Dissolved Oxygen, MPN : Most Probable Number.
2. Standard values are imposed based on daily averages. Similar criteria are applied to the standard values of the lakes and coastal areas.
3. At intake for agriculture, pH should be between 6.0 and 7.5 and DO shall be > 5mg/L. The same criteria are applied to lakes.
3. Standard values are applied to unfiltered sample.

Table 8 EQS for conservation of the living environment in Japanese lakes (natural lakes and reservoirs with volumes exceed 10x10^6 m^3)

Class	Item	Standard Value				
	Water Use	pH	COD	SS	DO	Total Coliform
AA	Water supply class 1, fishery class 1	6.5-8.5	≤1 mg/L	≤1 mg/L	≥7.5 mg/L	≤50 MPN/100ml
A	Water supply classes 2 and 3, fishery class 2, bathing	6.5-8.5	≤3 mg/L	≤5 mg/L	≥7.5 mg/L	≤1000 MPN/100ml
B	Fishery class 3, industrial water class 1, agricultural water	6.5-8.5	≤5 mg/L	≤15 mg/L	≥5 mg/L	-
C	Industrial water class 2 and conservation of the environment	6.5-8.5	≤8 mg/L	No Floating garbage	≥2 mg/L	-

Note: Standard values are applied to unfiltered sample. The analysis of COD is $KMnO_4$ method.

Table 9. EQS for TN &TP in Japanese lakes for conservation of living environment

Class	Item	Standard Value	
	Water Use	Total Nitrogen	Total Phosphorus
I	Conservation of natural environment and uses listed in II-V	≤0.1 mg/L	≤0.005 mg/L
II	Water supply classes 1, 2, and 3 (except special types), fishery class 1, bathing	≤0.2 mg/L	≤0.01 mg/L
III	Water supply class 3 (special types)	≤0.4 mg/L	≤0.03 mg/L
IV	Fishery class 2	≤0.6 mg/L	≤0.05 mg/L
V	Fishery class 3, industrial water, agricultural water, and conservation of the environment	≤1 mg/L	≤0.1 mg/L

Notes: 1.Standard values are the annual mean.
2. Standard values are applicable only to the lakes and reservoirs where phytoplankton bloom may occur and standard values for total nitrogen are applicable to lakes and reservoirs where nitrogen limits phytoplankton growth.
3. Standard values for total phosphorus are not applicable to agricultural irrigation water
4. Standard values are applied to unfiltered sample

Table 10. EQS for TN &TP in Japanese coastal areas for conservation of living environment

Class	Item	Standard Value	
	Water Use	Total Nitrogen	Total Phosphorus
I	Conservation of the natural environment and uses listed in II-IV (except fishery classes 2 and 3)	≤0.2 mg/L	≤0.02 mg/L
II	Fishery class 1, bathing, and the uses listed in III-IV (except fishery classes 2 and 3)	≤0.3 mg/L	≤0.03 mg/L
III	Fishery class 2 and the uses listed in IV (except fishery class 3)	≤0.6 mg/L	≤0.05 mg/L
IV	Fishery class 3, industrial water, and conservation of habitable environments for marine biota	≤1 mg/L	≤0.09 mg/L

Notes : 1. Standard values are the annual mean.
2. Standard values are applicable only to marine areas where marine phytoplankton blooms may occur.
3. Standard values are applied to unfiltered sample

Table 11 EQS for conservation of the living environment in Japanese coastal areas

Class	Item	Standard Value				
	Water Use	pH	COD	DO	Total Coliform	PHC
A	Fishery class 1, bathing, conservation of the natural environment	7.8-8.3	≤2 mg/L	≥7.5 mg/L	≤1000 MPN/100ml	Not detectable
B	Fishery class 2, industrial water	7.8-8.3	≤3 mg/L	≥5 mg/L	-	Not detectable
C	Conservation of the environment	7.8-8.3	≤8 mg/L	≥2 mg/L	-	-

Notes : 1. COD: Chemical Oxygen Demand, DO: Dissolved Oxygen, MPN: Most Probable Number; PHC petroleum hydrocarbons
2. Total coliform should be less than 70MPN/100ml for the fishery of class 1 to the cultivations of oyster for eating raw.
3. The analysis method of COD is $KMnO_4$ method
4. Standard values are applied to unfiltered sample

Table 12 Substances to be monitored, waters classifications, and guideline values for the conservation of aquatic organisms

substances	Water Area	Class	Guideline Value
Chloroform	River and Lakes	Aquatic Organisms A	0.7 mg/L or less
		Aquatic Organisms special A	0.006 mg/L or less
		Aquatic Organisms B	3 mg/L or less
	Coastal Areas	Aquatic Organisms A	0.8 mg/L or less
Phenol	River and Lakes	Aquatic Organisms A	0.05 mg/L or less
		Aquatic Organisms special A	0.01 mg/L or less
		Aquatic Organisms B	0.08 mg/L or less
		Aquatic Organisms special B	0.01 mg/L or less
	Coastal Areas	Aquatic Organisms A	2 mg/L or less
		Aquatic Organisms special A	0.2 mg/L or less
Formaldehyde	River and Lakes	All Aquatic Organisms	1 mg/L or less
	Coastal Areas	Aquatic Organisms A	0.3 mg/L or less
		Aquatic Organisms special A	0.03 mg/L or less

Notes : Standard values are applied to unfiltered sample

The national effluent standards are uniformly applied in Japan. They are made up of two categories: the standards for protecting human health (28 items including cadmium and cyanide) and the standards for protecting the living environment (15 items) (Table 13). For some specified establishes, provisional effluent standards are applied. Prefectures may set stricter effluent standards than the national effluent standards.

«Not detectable» means that when the substances are measured by the method specified by the Minister of the Environment based on the Article 2 of the provision, the amount is less than the quantitative limit defined by that method. The effluent standards for As and its compounds are not applied for the present to the effluents of commercial facilities belong to hotel business industry using the hot spring which had actually gushed out when *the government ordinance as below was enforced.

Effluent standards related to the protection of the living environment in Japan have the following specific conditions when used:

1. The permissible limit by 'daily average' is provided for the average contaminated status of effluent per day.

2. The effluent standards listed in Table 13 apply to the effluents of factories or commercial facilities which discharge 50m^3 or more of effluent per day on average.

3. The effluent standards for hydrogen ion activity (pH) and dissolved iron are not applied to the effluents of factories or commercial facilities belong to the sulfur mining industry (including mining industry which mines pyrites coexisting with sulfur).

4. The effluent standards for hydrogen ion activity (pH),copper, zinc, dissolved iron, dissolved manganese and chromium are not applied for the present to the effluents of commercial facilities belong to hotel business industry using the hot spring which had substantially gushed out when the *government ordinance as below was enforced.

5. The effluent standards for biochemical oxygen demand (BOD) exclusively apply to the effluents discharged into public waters other than seas and lakes, the effluent standards for chemical oxygen demand (COD) exclusively apply to the effluents discharged into seas and lakes.

6. The effluent standards for nitrogen content exclusively apply to effluents discharged into the lakes designated by the Minister of the Environment as being susceptible to lake phytoplankton blooms due to nitrogen, sea areas (including lakes which chlorine ion content of water is beyond 9,000mg/l, the same shall apply hereinafter) designated by the Minister of the Environment as being susceptible to marine phytoplankton blooms due to nitrogen, and public waters which flow into above water areas.

Table 13. Uniform National Effluent Standards (Last update: October 21, 2015)

Effluent Standards related to human health		**Effluent Standards related to the protection of the living environment**	
Substances	**Permissible limit**	**Substances**	**Permissible limit**
Cd	0.03 mg Cd/l	BOD	160 mg/l (DA 120 mg/l)
Cyanide compounds	1 mg CN/l	COD	160 mg/l (DA 120 mg/l)
Organic phosphorus compounds(Parathion)	1 mg/l	Suspended Solids	200 mg/l (DA 150 mg/l)
Pb	0.1 mg Pb/l	N-hexane Extracts (mineral oil)	5 mg/l
Cr6+	0.5 mg Cr(VI)/l	N-hexane Extracts (bio fats)	30 mg/l
AS	0.1 mg As/l	Phenols	5 mg/l
Hg	0.005 mg Hg/l	Cu	3 mg/l
MeHg	Not detectable	Zn	2 mg/l
PCBs	0.003 mg/l	Dissolved Fe	10 mg/l
Trichloroethylene	0.1 mg/l	Dissolved Mn	10 mg/l
Tetrachloroethylene	0.1 mg/l	Cr	2 mg/l
Dichloromethane	0.2 mg/l	Coliform groups	Daily Average 3000/cm^3
Carbon Tetrachloride	0.02 mg/l	Nitrogen	120 mg/l (DA 60 mg/l)
1, 2-Dichloro ethane	0.04 mg/l	Phosphorus	16 mg/l (DA 8 mg/l)
1, 1-Dichloro ethylene	1mg/l		
1, 2-Dichloro ethylene	0.4 mg/l		
1, 1, 1-Trichloro ethane	3 mg/l		
1, 1, 2-Trichloro ethane	0.06 mg/l		
1, 3-Dichloropropene	0.02 mg/l		
Thiram	0.06 mg/l		
Simazine	0.03 mg/l		
Thiobencarb	0.2 mg/l		
Benzene	0.1 mg/l		
Se	0.1 mg Se/l		
B in fresh waters	10		
B in coastal waters	230		
F in fresh waters	8		
F in coastal waters	15		
DIN (NH_4, NO_3, NO_2)	100		
1,4-Dioxane	0.5mg/l		

DA – daily averaged;

The effluent standards for phosphorus content exclusively apply to effluents discharged into *the lakes designated by the Minister of the Environment as being susceptible to lake phytoplankton blooms due to phosphorus, *the sea areas designated by the Minister of the Environment as being susceptible to marine phytoplankton blooms due to phosphorus, and public waters which flow into the above water areas.

Under the Water Pollution Control Law of Japan, the monitoring of water quality in the public water bodies and the groundwater should be conducted for observing the level of compliance with the applicable environmental quality standards and effluent standard for factories and businesses.

The governors of each prefecture shall, after consulting with the chiefs of the local offices of national administrative agencies and city governments, establish an annual program for the measurement of water quality in the public water bodies that belong to the prefecture. The governor of a prefecture and government ordinance mayor shall measure the water quality in the public water bodies and groundwater in compliance with this program and report the findings of the measurements that shall be published by governor of the prefecture.

Moreover, an operating company which discharges effluents from specified factories shall measure the pollutant levels in their effluents and keep records of the measured findings according to this law. The governor of the prefecture and government ordinance mayor can request the report from the factories and business establishments or conduct on-site inspection, if necessary to verify compliance with the effluent standards, and may issue whatever administrative orders are necessary to improve conditions in factories and establishments to achieve compliance.

The total number of the monitoring points in public water bodies is about 8,600 points (results in 2002) in all of Japan. The monitoring points that represent the water quality of the NOWPAP region for evaluating achievement of the EQS are defined as the "environmental standard points". The environmental standard points are provided so that at least one exists in each water region where the water classification is applied. In addition, supplementary points can be defined. The total number of the environmental standard points and the supplementary points on the first class rivers (35 rivers NOWPAP) is 247 in the NOWPAP region.

Various monitoring programs on the sea water pollution are implemented in Japan by relevant organizations such as administrative bodies, research institutions and universities. Monitoring programs implemented by the Ministry of the Environment, in addition to the Marine Environment Monitoring Survey, include the Environment survey of Chemical Contamination, the Public Water Survey, and the Wide-area Comprehensive Water Quality Survey.

Korea. Full-scaled management on water resources in Korea based on the Water Quality Conservation Act in 1990s was the first nationwide water quality conservation plan focused on counter-measures against major pollution incidents. It was not very successful in terms of water quality improvement since it was based on administrative districts and focused on restricting the point sources in upstream regions through regulating wastewater-discharging facilities. Despite these measures, various pollution incidents and water quality deterioration have continued to occur in some water supply sources. Although additional measures were implemented, the water quality was not improved. After recognizing the limitations of such a regulatory approach and conventional regulations by concentration, the river basin management has been incorporated to the water policies, namely TWPLMS (Total Water Pollution Load Management System), since the 2000s. Comparison between regulation by concentration and TPLMS in Korea is presented in Table 14.

Land-use regulation which restricts certain point sources in specific regions is a key policy to prevent water pollution in Korea. Regulating targets encompasses 'Special Management District' for water quality conservation under the Framework Act on Environmental Policy, ‘Water Supply Protection Area’ under the Water Supply and Waterworks Installation Act, ‘Riparian Buffer Zone’ under the Act on Water Management and Resident Support in the Four Major River Basins, and ‘Discharging Facility Installation Restriction Area’ under the Water Quality and Aquatic Ecosystem Conservation Act.

Table 14. Advantages and limitation of regulation of water quality by concentration and TPLMS approaches

Category	Regulation by “Concentration”	TWPLMS
Regulation method	Control of pollution concentration in the sewage	Control of total pollution amount in the sewage
Merits	- Easiness to fix the standards - Easiness to execute and the low expenses	- Effective control - Equity among the polluters
Demerits	- Ineffective control - Disadvantageous to small-scale discharger	- Difficulty to calculate the permissible discharge amount - Difficulty to execute and the high expenses

The Ministry of Environment (MOE) has established a Water Pollution Control Center for monitoring and preventing water pollution, where a particular concern was given for maintaining water quality during the FMRP. As of December 2013, the network has been installed near the basin of the four major rivers in Korea (70 locations and 67 automatic water quality monitoring stations) and operated to detect pollution incidents effectively (Fig.17, 18, and Table 15) (KECO, 2012).

Table 15. Established locations for management of National Water Quality monitoring system in the four major rivers, Korea.

Region	River	Lake	Total
Han River	21	2	23
Geum River	11	2	13
Youngsan River	7	3	10
Nakdong River	24	-	24
Total	63	7	70

Water quality targets in the National Water Quality Monitoring set required (common) items but also includes several optional (selected) measures if needed (Table 16). As shown in Table 17, the Ambient Water Quality Standard for the living environment is established for rivers. It consists of seven grades and definite grades is assigned to each river and lake as for the water quality target.

Table 16. Items of National Water Quality Monitoring System for water quality monitoring in rivers and lakes, Korea

Objective of installation	Items	
	Required items	Optional items
Water monitoring	Temperature, pH, DO, TOC, Electric conductivity	Turbidity, TN, NH_3-N, TP, PO_4-P, Phenol, Chl-a, Heavy metal, VOCs*, Bio-monitoring
Water management		Turbidity, TN, TP

*VOCs (Benzene, Carbon tetrachloride, Ehtylbenzene, Toluene, (o,m,p-)Xylene, dichloromethane, Tetrachloroethylene, Trichloroethylene, 1.1.1.-trichloroethane

The peculiarity of the monitoring of surface waters in Korea is a wide usage of the Water Telemonitoring System (TMS). The system has been established since 2007, as an online system to monitor the discharge of wastewater and sewage contaminants from environmental facilities (public wastewater and/or sewage treatment plants) in real time (24 hours) (Fig. 17). Of note, the permissible discharge standard of contaminants has been differently applied depending on the location of discharging plants (or facilities).

Table 17. Ambient Water Quality Standards of rivers – Living environment (modified from MOE, 2012).

Grade		Criteria								
		pH	BOD (mg/L)	COD (mg/L)	TOC (mg/L)	SS (mg/L)	DO (mg/L)	TP (mg/L)	Coliforms (groups/100mL)	
									Total	Fecal
Very good	I_a	6.5~8.5	1 or less	2 or less	2 or less	25 or less	7.5 or more	0.02 or less	50 or less	10 or less
Good	I_b	6.5~8.5	2 or less	4 or less	3 or less	25 or less	5.0 or more	0.04 or less	500 or less	100 or less
Somewhat good	II	6.5~8.5	3 or less	5 or less	4 or less	25 or less	5.0 or more	0.1 or less	1,000 or less	200 or less
Average	III	6.5~8.5	5 or less	7 or less	5 or less	25 or less	2.0 or more	0.2 or less	5,000 or less	1,000 or less
Somewhat poor	IV	6.0~8.5	8 or less	9 or less	6 or less	100 or less	2.0 or more	0.3 or less		
Poor	V	6.0~8.5	10 or less	11 or less	8 or less	No floating debris	2.0 or more	0.5 or less		
Very poor	VI		More than 10	More than 10	More than 8		Less than 2.0	More than 0.5		

The basic parameters for water quality monitoring include BOD, COD, and SS (Table 18), but not limited to other parameters such as pH, TN, TP, coliforms, phenols, benzene series, and heavy metals etc. if available. Once the level of contamination is exceeded, the staff performs a field inspection. Via the field inspection, if the contaminant level exceeds the discharge standard either in continuous monitoring during three hours or records more than 10 times of over level in a week, a penalty will be given at higher level. Water TMS installation is located in 939 places as of June 2017 (Fig. 17).

Table 18. Discharge allowance standard for environmental facilities such as public wastewater or sewage treatment plants.

Area classification	Amount of discharge sewage and wastewater					
	More than 2000 m^3/day			Less than 2000 m^3/day		
	BOD (mg/L)	COD (mg/L)	SS (mg/L)	BOD (mg/L)	COD (mg/L)	SS (mg/L)
Clear Area	< 30	<40	<30	<40	<50	<40
Area A	<60	< 70	<60	<80	<90	<80
Area B	<80	<90	<80	<120	<130	<120
Special Area	<30	<40	<30	<30	<40	<30

*Classified according to the management or conservation criteria of water system and surrounding environment in corresponding region.

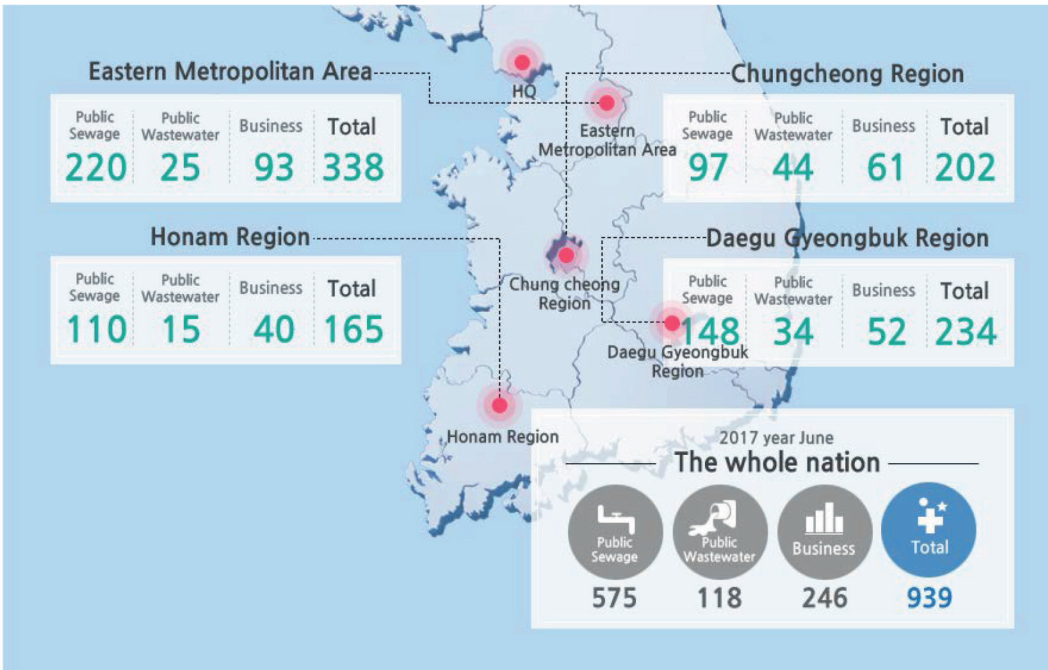


Figure 17. Water TMS installation status (www.keco.or.kr).

The sediment monitoring network was newly introduced in the second half of 2011 to assess the sediment quality and its impact on water quality and aquatic ecosystems. As of December 2013, the network under operation was 177 locations. The results of the water quality survey can be obtained through the government information system (Water Information System, http://water.nier.go.kr) (NIER, 2015).

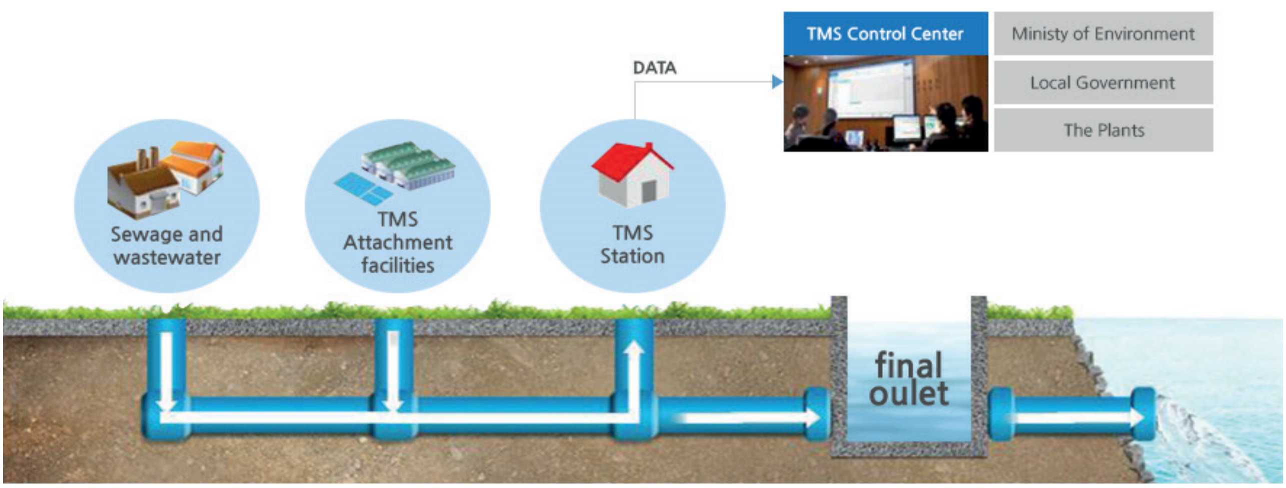


Figure 18. Overview of water TMS (www.keco.or.kr).

The Total Water Pollution Load Management System (TWPLMS) is a water quality management system which calculates and manages the allowable pollutant's load which can meet the water quality target for each watershed reach. The target and allowable loads for each river watershed are determined by scientific evidence. The total allowable load is assigned to each local government in the watershed and the discharged load is strictly managed under the permissible level (Fig. 19).

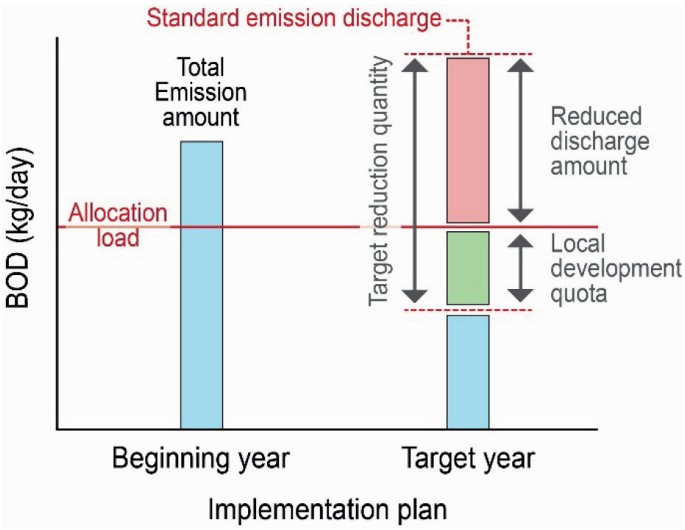


Figure 19. A concept of a total Water Pollution Load Management System for river (TWPLMS).

The loading amount is a loading, which pollutants give to water body such as sea, river, lake, and others. As the unit, a kilogram per day (kg day^{-1}), which is a basic unit for TWPLMS is generally used and it can be obtained through multiplying the amount of wastewater to the concertation of pollutants.

In Korea as of March 2014, TWPLMS has been implemented at a total of 114 local governments at the four major rivers. At the beginning BOD was the only parameter of TWPLMS, but TP was added from stage 2 (2011-2015).

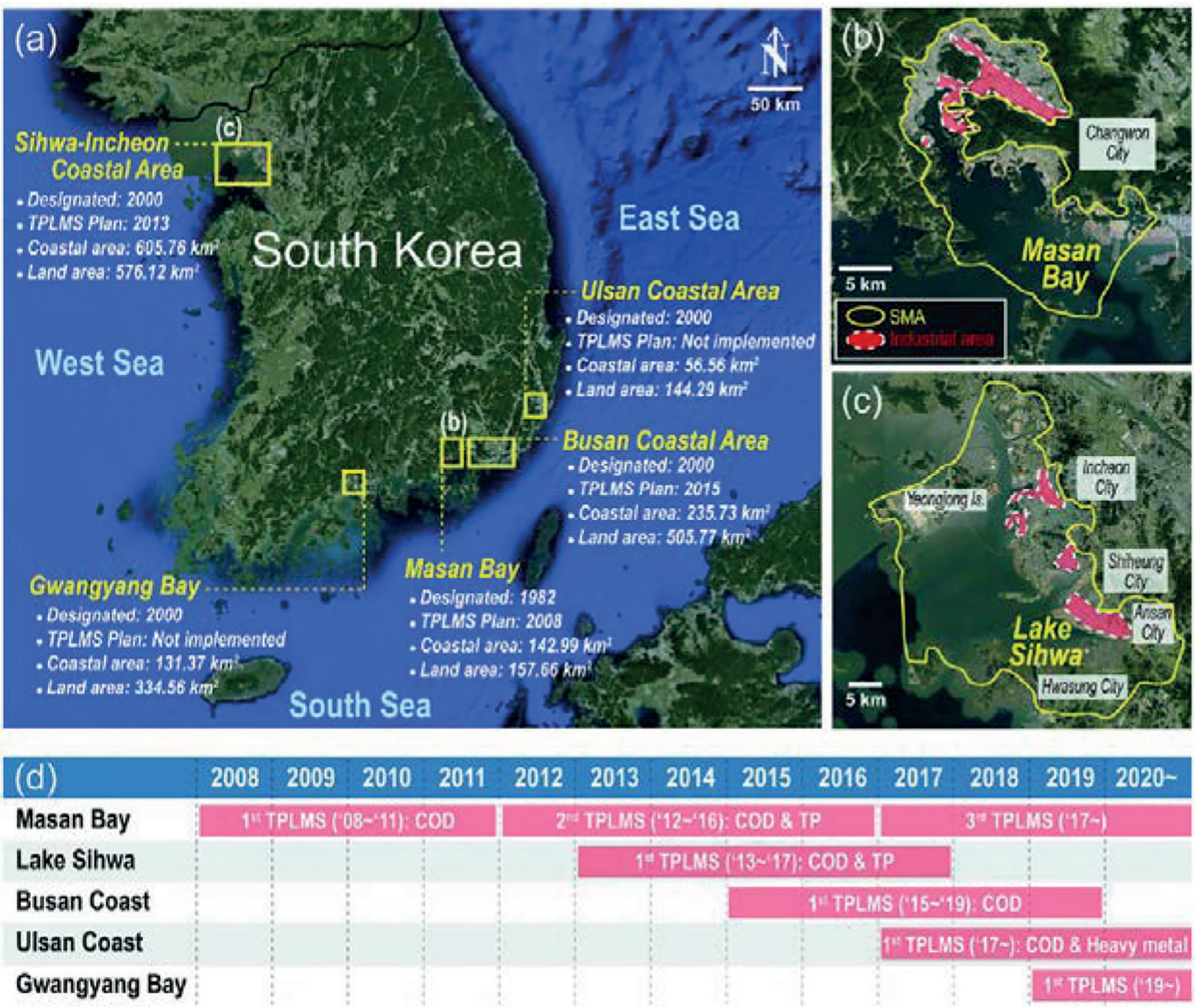


Figure 20. The map showing the (a) special management areas (SMAs) in Korea, with (b) and (c) detailing the areas of focus in the present study. (d) A plan for the implementation of the total pollution load management system (TPLMS) in the five SMAs (COD: chemical oxygen demand; TP: total phosphorous) (Lee et al., 2016).

The TWPLMS implementation process is (1) establishment of the water quality target and standard discharge at the downstream of a river to manage, (2) calculation of pollutant loading amount emitted from a target watershed using a scientific method while considering the condition of environmental management on the watershed, development plan, (3) completing a master plan for whole managing, and finally (4) proceeding with convergence by using the water quality modelling method by specialists, seminar, and an adjustment.

Due to settings of the Korean coasts, surrounded by the sea on three sides, the coastal contamination from land-driven pollutants via river would be an inevitable environmental problem. Thus, the Korean government manages marine areas according to marine environment standards. If it is difficult to maintain the standards or if serious obstacles prevent conservation of marine environments and ecosystems, the Minister designates the SMA, including land that could potentially contribute to this designated marine pollution (Lee et al., 2016).

Up to now, five coastal areas of Korea have been designated as SMA and implemented TPLMS (cf. TWPLMS for a river system) to limit the input of contaminants from the rivers and streams (Fig. 20).

Russia. The Federal Service on Hydrometeorology and Environmental Monitoring (ROSHYDROMET) is responsible for routine monitoring in Russia. Primorskii Krai Office on Hydrometeorology and Environmental Monitoring implements monitoring of contamination of river and coastal waters in Primorskii Krai according to State Monitoring Programs. Sakhalin Office on Hydrometeorology and Environmental Monitoring carries out such activity within and around Sakhalin Is.

The general objectives of the State Monitoring Program in Russia are: 1) Observation on the water quality at the background sites, and near the possible sources of contamination due to human activity as well; 2) The assessment and prediction (forecast) of the water quality changes under the influence of the natural and human factors; 3) Ensuring the needs of state (governmental), business and human communities in the reliable information about ambient water quality and its changes for the subsequent use for the prevention/remediation of environmental damage.

Water quality assessments in Russia are based on the compliance with maximum permissible concentrations (MPC is an analogue of EQS). There are three sets of MPC in ambient water: (1) for the drinking water; (2) for the water of domestic, drinking and cultural uses – "public waters" (both according to former SanPIN 2.1.4.559-96, from the July 2003 – GN 2.1.2.1315-03); (3) for the water used for the fishery purposes (Agriculture Ministry Order #552 from 13.12.2016). All substances are divided into four classes of danger (toxicity level - TL) according to their toxicity for people and/or fish, cumulative and prolonged effects, etc: the 1st class – extremely dangerous, the 2nd class – high dangerous, the 3rd class – dangerous, the 4th class – moderately dangerous.

MPC for the most common, potentially hazardous chemical substances in water for different types of water use are presented in Table 19. MPC are also set for more than 600 organic chemical substances in drinking water, more than 1,000 chemical substances in public water, and more than 800 chemical substances in water used for fisheries.

MPC for drinking water are a mandatory hygienic norm with no exceptions. For some public water and water used for fisheries, MPC are an environmental norm, that is, there is an option to exceed MPC with deterioration of water quality. Such cases are the subjects for special investigation procedures.

The amount and quality of all types of municipal and industrial wastewater are controlled by regional agencies of the Federal Service for Environmental, Technological and Nuclear Supervision.

The key is in setting Maximum Permissible Discharges of wastes – MPD. MPD are developed by scientific and engineering organizations for different water users and are approved by the Federal Service for Environmental, Technological and Nuclear Supervision, and Ministry of Natural Resources. The regional offices of the Ministry of Natural Resources are responsible for ground water quality.

Table 19. Maximum permissible concentration of chemical substances (mg/l) in waters used for the different purposes in Russia

Parameter	Drinking	"Public" waters	Fishery purpose	TL
pH	6-9	6-9	6.5-8.5	4
Mineralization	1000 mg/l	1000 mg/l	1000	4
BOD5	nd	nd	2.0	4
COD	5.0 mg/l ($KMnO_4$)	5.0 mg/l ($K_2Cr_2O_7$)	15 ($K_2Cr_2O_7$)	4
PHC (petroleum hydrocarbons)	0.1 mg/l	0.1 mg/l	0.05	3
Detergents (Surfactants)	0.5 mg/l	0.5 mg/l	0.1	4
Phenols (summary)	0.25 mg/l	0.25 mg/l	0.001	3
Al^{3+}	0.5 mg/l	0.5	0.04	2/4
Be^{2+}	0.0002 mg/l	0.001	0.0003	1/2
B	0.5 mg/l	0.5	10*, 0.1	2/4
Fe	0.3 mg/l	0.3	0.05*, 0.1	3/4
Cd	0.001 mg/l	0.001	0.01*,0.005	2
Mn, Ni	0.1 mg/l	0.1	0.05*, 0.01	3/4
Cu	1.0 mg/l	1.0	0.005*, 0.001	3
As	0.05 mg/l	0.05	0.01*, 0.05	2/3
Se	0.01 mg/l	0.01	0.002	2
Hg	0.0005 mg/l	0.0005	0.0001*, $<10^{-5}$	1
Cr	0.05 Cr^{6+}, 0.5 Cr^{3+}		0.02Cr^{6+},0.07Cr^{3+}	3
Zn	5 mg/l	1.0	0.05*, 0.01	3
Pb	0.03 mg/l	0.03	0.01*, 0.006	2
$N-NO_3^-$	10 mg/l	10	9.1	3
$N-NO_2^-$	0.75	0.8	0.02	2
$N-NH_4^-$	nd	1.0	0.4	3/4
DIP (PO_4)	nd	nd	0.05	2
F^-	1.2-1.5 mg/l	1.5	0.75	2/3
CN^-	0.035 mg/l	0.1	0.05	2/3
HCH	0.002 mg/l	0.02	<0.00001	1
DDT (summ of isomers)	0.002 mg/l	0.1	<0.00001	2/1
PCBs	0.001	0.001	0.0001	1-2

* - for sea water only; nd – not determined; TL for drinking water/TL for fisheries

The quantitative criteria for observed concentrations are established to classify pollution events in ambient water (Table 20). According to these criteria, all events are divided into pollution (exceeding MPC), high pollution (exceeding 5-30 MPC), and extremely high pollution (exceeding 20-50 MPC).

Table 20. Water quality criteria based on concentration of chemical substances (mg/l)

Parameter	Type of water use	Pollution (>MPC)	High pollution	Extremely high pollution
DO	fisheries		< 3.0	< 2.0
BOD5	fisheries	2.0	> 10	> 40
$COD(K_2Cr_2O_7)$	fisheries	15	> 150	> 750
$N\text{-}NH_4^+$	fisheries	0.4	> 4.0	> 20
$N\text{-}NO_2^-$	fisheries	0.02	> 0.2	> 1.0
$N\text{-}NO_3^-$	fisheries	9.1	> 91	> 910
$P\text{-}PO_4$	fisheries	0.05	> 0.5	> 2.5
SO_4^{2-}	fisheries	100	> 1000	> 5000
Fe	hygienic	0.1	> 3.0	> 5.0
Al	fisheries	0.04	> 0.4	> 2.0
Zn, Ni	fisheries	0.01	> 0.1	> 0.5
Mn	fisheries	0.01	> 0.3	> 0.5
Cu	fisheries	0.001	> 0.03	> 0.05
Cd	hygienic	0.005	> 0.015	> 0.025
Pb^{2+}	hygienic	0.006	> 0.018	> 0.03
Cr^{6+}	fisheries	0.02	> 0.2	> 1.0
PHC	fisheries	0.05	> 1.5	> 2.5
Detergents	fisheries	0.1	> 1.0	> 5.0
Phenols	fisheries	0.001	> 0.030	> 0.050
HCH, DDTs	fisheries	0.00001	> 0.00003	> 0.00005
F^-	fisheries	0.75	> 7.5	> 37.5
B	hygienic	2.67	> 26.7	> 133.5
H_2S	fisheries	0.00001	> 0.00010	> 0.00050

The Office for Supervising the Protection of Consumer's Rights and Human Welfare, which is an agency of the Ministry of Health and Social Development, is the executive authority responsible for establishing sanitary hygienic MPC. The State Fishery Agency, a subdivision of the Ministry of Agriculture, is responsible for establishing and confirming MPC for fisheries water.

For the time being State Monitoring network of surface water within Primorskii Krai consists of 43 stations, including 20 that report monthly and 13 quarterly (4 times/yr) reported. Monitoring items at monthly reported by the stations include t°C, pH, conductivity, DO, SS, BOD5, COD_{Cr}, and 2-3 characteristic pollutants. On the quarterly operated stations the additional parameters are determined including macro-ions, $N\text{-}NH_4$, NO_3, NO_2, PO_4, Fe, Si, oil products (PHC), PAHs, trace metals, POPs. Monitoring of surface waters of Sakhalin Is. by ROSHYDROMET Sakhalin branch is carried out at the 40 stations reported monthly.

Seawater quality is controlled by the same regional branches of ROSHYDROMET service: at the 39 stations in the Peter the Great Bay, and at the 11 stations around south part of Sakhalin Is. The program of observation at the sea area stations includes DO, BOD, nutrients, petroleum hydrocarbons (PHC), phenols, trace metals in water column, and trace metals, PHC and phenols in bottom sediments. Pesticides (DDT and HCH) in water and bottom sediments are determined additionally at the Peter the Great Bay.

The legislative background of monitoring activities in the Russian Federation is the FEDERAL LAW «ON ENVIRONMENTAL PROTECTION» (No. 7-FZ of January 10, 2002). The main goal of this Law is to promote formation and strengthening of the ecological law enforcement and maintenance of ecological safety in the territory of the Russian Federation and republics in structure of the Russian Federation. In Article 1 of this Law the following definition is given: "Environmental monitoring (state ecological monitoring) is a comprehensive system of observing the condition of the environment, assessing and forecasting of environmental changes resulted from natural and man-made factors… The state environmental monitoring (the state ecological monitoring) is the environmental monitoring performed by the governmental bodies of the Russian Federation and the governmental bodies of the subjects of the Russian Federation".

Another legislative Act on this issue is The WATER CODE of the RUSSIAN FEDERATION (October 18, 1995). Article 78 of this Law "The state monitoring of water objects" gives the following definition: "The state monitoring of water objects represents a system of regular observations for hydrological or hydro-geological and hydrochemical parameters of their condition, providing gathering, transfer and processing of obtained information aimed at up-date revealing of negative processes, forecasting of their development, prevention of harmful consequences and definition of efficiency degree of water protection measures.

Other legislative and normative documents regulating activity in the field of ecological monitoring include:

« THE AGREEMENT ON COOPERATION IN THE FIELD OF ECOLOGICAL MONITORING OF THE STATES - PARTICIPANTS OF THE CIS » (it is approved by the CIS of January 13, 1999 and commissioned within the territory of the Russian Federation by the decision of the Government of the Russian Federation No.299 of April 04,2000);

The Decision of the Government of the Russian Federation No. 177 of March 30,2003 « ON ORGANIZATION AND REALIZATION OF THE STATE MONITORING OF ENVIRONMENT (THE STATE ECOLOGICAL MONITORING) »;

The Decisions of Heads of administrations of the subjects of the Russian Federation on creation of territorial subsystems of ecological monitoring (48 subjects of the Russian Federation);

Moreover a number of the articles of «The Federal law on wildlife» (No.52 - FZ of April 24,1995), «On a special economic zone » (Article 28), « On a continental shelf of the Russian Federation » (Article 33), « On special protected natural territories » (Article 7), «On protection of Lake Baikal» (Article 20) concern different issues of the organization and implementation of monitoring of water quality.

5. Features in the monitoring methods in the NOWPAP countries

It is obvious from the above chapter that each NOWPAP country has own system of the monitoring of surface (rivers and lakes) and coastal waters quality. It can hamper the correct comparison of the assessments and evaluations of water quality issues between countries. It is especially important for the transboundary water objects of any kinds: rivers, lakes, and sea areas.

There are three types (levels) of possible inconsistency at the evaluation of water quality due to different features of monitoring methods and procedures in the NOWPAP countries.

The first one is connected with some differences in the treatment and analysis for hydrochemical parameters. Preservation methods are similar in all NOWPAP countries. The key discrepancy is in data on nutrients and metals because Russia and Korea (for nutrients) use filtered samples and China and Japan – unfiltered ones (Table 21). Another issue is a COD using $KMnO_4$ as an oxidant in China, Japan and Korea, and COD using a stronger reagent $K_2Cr_2O_7$ in Russia. The next issue is the widespread use of total nitrogen (TN) and total phosphorus (TP) for the assessment of water quality in all NOWPAP countries except Russia. Besides, in Russia before 2017 and after that ammonia nitrogen was analyzed by different methods with Nessler and with indophenol reagent, respectively. As a result, some systematic decrease is observed for ammonia nitrogen. All these differences are possible to take into account at the comparison and discussion of the water quality status in the NOWPAP countries including the transboundary water objects. The Chinese-Russian commission on the monitoring of the Amur River water quality is a good example of such joint work since 2008.

Table 21. Water sample preservation methods used at the monitoring in NOWPAP countries

Parameter	China unfiltered*	Japan unfiltered	Korea unfiltered/filtered	Russia unfiltered/filtered**
COD_{Mn}	0-5° C	0-5° C	u, H_2SO_4 (pH<2)	u 0-5° C
COD_{Cr}	H_2SO_4 (pH<2)	nd	nd	u 0-5° C
BOD_5	0-5° C	0-5° C	u, 0-5° C	u 0-5° C
NH_4^- NO_3, PO_4	H_2SO_4 (pH<2)	0-5° C	f, H_2SO_4 (pH<2)	f, $CHCl_3$
T P	H_2SO_4 (pH<2)	0-5° C	u, H_2SO_4 (pH<2)	nd
T N	H_2SO_4 (pH<2)	0-5° C	u, H_2SO_4 (pH<2)	nd
Cu, Zn, Cd,Pb	HNO_3(pH<1)	HCl (pH<1)	u, HNO_3 (pH<1)	f, HNO_3(pH<1)
Se, As	HNO_3(pH<1)	HCl (pH<1)	u, HNO_3 (pH<1)	f, HNO_3(pH<1)
Hg	HNO_3(pH<1)	HCl (pH<1)	u, HNO_3(pH<1)	f, HNO_3(pH<1)
Cr^{6+}	NaOH (pH8-9)	HCl (pH<1)	u, 0-5° C	f, 0-5° C
CN^-	NaOH (pH8-9)	NaOH, pH>11	u, NaOH (pH>11)	u, NaOH (pH>11)
V-phen	H_3PO_4(pH<2)	nd	u, H_2SO_4 (pH<4)	u 0-5° C
Oils (PHC)	HCl (pH<2)	nd	u, H2SO4 (pH<2)	u, CCl_4 (2ml/l)
Surfactants	H_2SO_4(pH<2)	nd	u, 0-5° C	u, $CHCl_3$(2ml/l)

* 30' standing after sampling with further decantation of the upper water layer for analysis (GB3838-2002); ** - filtration through 0.45 μm filter; nd - not determined or not used in regular monitoring of water quality.

The second type of problems can arise at the comparison of observed values of parameters with ecological quality standards due to some differences of latter ones (Table. 22). The main differences in the water quality standards are as follows: (1) WQS and EQS for BOD5 and COD_{Mn} in Japan and Korea are significantly tougher than in Russia and China; (2) WQS and EQS for TN (total nitrogen) in China, Korea and Japan are stricter than MPC for dissolved nitrate (NO_3^-) in Russia; (3) MPC for dissolved forms of metals in Russia are tougher as a rule, than in other countries, but closer in some cases to the MDL, and in some cases – to the natural level . At the same time there is an obvious general similarity in water quality standards - EQS , WQS, MPC - in different countries (Table. 22), and it is possible to distinguish and to compare "clean" waters in all NOWPAP countries.

Table 22. Comparison of Some EQS (mg/l) for the surface and sea waters in NOWPAP countries

Parameter	China*	Japan**	Korea***	Russia****	MDL, mg/L
DO ≥	7.5	7.5	7.5	5	0.2; 0.5
COD_{Mn}≤	2	1(lakes)	1(lakes)	5	0.5
COD_{Cr}≤	15	nd	nd	15	1.5
BOD_5 ≤	3	1 (rivers)	1	2	0.4; 2.0
NH_4- ≤	0.15	nd	nd	0.4	0.002; 0.05
NO_3^- <	nd	10	nd	9.1	0.2; 0.01; 0.5
T P ≤	0.02	0.05	0.01 (lakes)	0.05[1]	0.001; 0.01
T N ≤	0.2	0.1	0.2 (lakes)	9.5[1]	0.002; 0.05
Cu ≤	0.01	0.04	nd	0.001/0.005*	0.001; 0.005
Zn ≤	0.05	0.03	nd	0.01/0.05*	0.0005-0.05
F- ≤	1.0	0.8	nd	0.75	0.05; 0.2
Se ≤	0.01	0.01	nd	0.01	0.002
As ≤	0.05	0.01	0.05	0.005	0.0005; 0.005
Hg ≤	0.00005	0.0005	BDL	0.0001*/0.0005	0.00005; 0.0005
Cd ≤	0.001	0.01	0.01	0.005/0.01*	0.0005; 0.002
Pb ≤	0.01	0.01	0.1	0.006	0.005; 0.040
Cr^6+ ≤	0.01	0.05	0.05	0.02	0.004; 0.010
CN-≤	0.005	BDL	BDL	0.035	0.01; 0.1
V-phen≤	0.002	nd	0.005	0.002	0.002; 0.005
Oils (PHC) ≤	0.05	nd	nd	0.05	0.01; 0.02
surfactant≤	0.2	nd	0.5	0.1	0.01; 0.05

All standards in mg/L,; MDL – minimum detection limit according to working documents of NOWPAP countries.
*- EQS for Grade I waters; ** - EQS for Grade AA waters and human health protection; *** - WQS for Grade I Water for rivers and lakes; **** - the most strictest MPC for fishery purpose waters; nd – not determined or not used; BDL - should be below detection limit; [1] – for dissolved forms (PO_4 and NO_3+NH_4+NO_2).

The third type of the problems at the comparative analysis of water quality arises when we operate with the “graded” values. Even within the country “grade” of water can be determined by different contaminants, and waters highly polluted by nutrients or BOD due to municipal sewages, and waters highly polluted by Cd or Zn due to mining or industrial activities, are definitely different cases, though both waters can have the same grade of pollution. The situation becomes much more difficult when we try to compare “graded” scores in different countries. It looks very problematic to get reasonable outputs from the comparison of “graded” assessments of water quality between different countries. The percentage of clean waters with Grade I (Grade AA) is only exception because the criteria of the distinguishing of this kind of waters are rather similar in all countries.

Besides the “Grades” of waters, a lot of different indexes have been suggested and used for the water quality assessments (e.g., Sutadian et al., 2016). In the NOWPAP countries the indices of water quality are officially used in China and Korea for the estuarine and coastal waters.

In China water quality of estuarine waters is assessed with respect to eutrophication problem using eutrophication index E

Here, DIP is dissolved inorganic phosphorus concentration (mg/L), DIN is dissolved inorganic nitrogen concentration (mg/L); COD is chemical oxygen demand concentration (mg/L). Oligotrophic conditions refer to E<1, slight eutrophication 1<E<2-3, and very serious eutrophication with E>15.

In Korea Water Quality Index (WQI) standards of estuary and coastal area (MEIS, 2018) have been developed. The WQI is calculated by the following equation:

$$WQI = 10\times[\text{bottom DO}+6]\times[(\text{Chl-}a+\text{Tr})/2]+4\times[(\text{DIN}+\text{DIP})/2]$$

Here are, dissolved oxygen (DO, mg/L), concentration of chlorophyll-*a* (Chl-*a*, μg/L), transparency (Tr, m), and dissolved inorganic nitrogen and phosphorus (DIN and DIP, μg/L). WQI varies from <20 to >60 with former being very good, and later being very bad.

In Russia, the specific combinatorial water pollution index (SCWPI) is officially used for the assessment of surface water quality by ROSHYDROMET Service. This index takes into account the frequency of the cases when observed data exceed the EQS (MPC) for each parameters, the degree of the exceedance for the given parameters, and the complexity of contamination. Later it is evaluated in accordance with the portion of parameters for which exceedance takes place. At least 15 hydrochemical parameters are recommended for the estimation of SCWPI, though comparative analysis with broadly used worldwide Water Quality Index of the Canadian Council of Ministers of the Environment (CCME, 2006) has shown that the number of parameters could be reduced.

The indexes of water quality are more prominent in terms of international appraisal and evaluation of water quality issues compare with information presented in form of percentage of graded waters.

The data reliability control is utmost important at the water quality monitoring. Therefore in each NOWPAP countries a big efforts are made for the proper QA/QC procedures.

In China QA/QC procedures for water quality monitoring are described in detail in the GB3838-2002 - Environmental Quality Criterion of the Surface Water - that includes guidelines for sampling, storage, preservation and analysis. For sea water all these issues are listed in the GB3097-1997.

In Japan each institution conducted analyses must obtain a license guaranteeing accuracy; this is mandated in the Measurement Law. It must also comply with ISO/IEC17025 (JIS Q 17025), an international standard for accurate management and skills testing based on ISO/IEC Guide 43-1 (the Japan Chemical Analysis Academy). In addition, the Ministry of the Environment established an accuracy management program concerned with the measurement of dioxins in the environment in 2000. The Ministry of Economy, Trade and Industry introduces also the specific measurement proof entrepreneur register system by enforcing “Law that revises a part of the measurement law” in April 2002, therefore public mechanism concerning to QA/QC of the analysis has been maintained.

In Korea the QA/QC procedures for surface water quality monitoring are implemented according to the rules set and approved by the MOE. The components of QA/QC include well calibrated equipment, use of only standard operating procedures, personnel training, rigorous quality control procedures (precision and accuracy), measurements that ensure data tracking and data verification.

The QA/QC procedures in Russia (Primorskii Krai Environmental Monitoring Center (EMC) are executed according to official recommendations of the State Committee of Russia on Standards, Metrology and Certification No. 52.24.509-96, “Implementation of Measures Regarding the Quality of Hydrochemical Information”, and No. 52.18.599-98 “Implementation of Inspections of the Accredited Laboratories (Centers).” External quality control by the State Hydrochemical Institute (Rostov-on-Don), Scientific-Production Association “Typhoon” (Obninsk) and the ADORC Center (Niigata) is regularly carried out to verify analytical techniques, thus using blind samples (at least once a year).

6. Present situation of river inputs of contaminants

In 2011, **China** National Environmental Monitoring Center optimized national surface water monitoring network. The number of monitoring stations increased from 758 to 972, and the list of reported parameters raised from 11 (t, Cond, pH, DO, $COD_{Mn,}$ BOD_5, NH_3-N, Oils, phenol, Hg, Pb) to 24 (plus COD, TP, TN, Cu, Zn, F^-, Se, As, Cd, Cr^{6+}, CN^-, surfactant, S^{2-}, large intestine bacteria). At the same time, no chemical composition specific data of each station has been reported since 2011.

The Yangtze (Changjiang), the Tumen, the Yalu, the Daliaohe-Liaohe, and the Dalinghe are the rivers directly inputted to the NOWPAP sea areas, and will be analysed further in this overview, though some other rivers like the Huaihe, Yihe, Huanhe, Haihe, and Luanhe rivers can influence on the NOWPAP sea areas indirectly. The same is true for the Songhua and Wissuli rivers which related with NOWPAP area through the Amur River runoff.

The averaged water quality of the Chinese rivers directly adjoining to the NOWPAP area at the stations closest to the mouth by the CNEMC monitoring in 2010 is presented in Table 23.

Table 23. Water quality parameters (mg/l) of Chinese rivers directly inputted to the NOWPAP area in 2010.

Rivers	DO	COD_{Mn}	BOD5	NH3-N	TN	TP	Oils	phenol	Hg	Pb
Yangtze	8.3	2.5	1.0	0.42	1.57	0.167	0.029	0.0027	0.01	0.009
Dalinghe	7.7	8.9	4.6	0.95		0.49	0.021	0.0034	0.08	0.005
Liaohe	8.3	9.1	7.8	2.03			0.293	0.0026	0.03	0.005
Daliaohe	4.6	8.0	4.0	1.45	2.12	0.088	0.023	0.0010	0.02	0.005
Tumen	7.1	13.8	2.8	0.35	1.45*	0.055*	0.017	0.0028	0.03	0.002
Yalu	9.7	2.6	1.0	0.17	1.04	0.026	0.025	0.0010	0.02	0.005
EQS Grade I	**7.5**	**2.0**	**3**	**0.15**	**0.2**	**0.02**	**0.05**	**0.002**	**0.00005**	**0.01**
EQS Grade III	**5.0**	**6.0**	**4**	**1.0**	**1.0**	**0.2**	**0.05**	**0.005**	**0.0001**	**0.05**
EQS Grade IV	**3.0**	**10**	**6**	**1.5**	**1.5**	**0.3**	**0.5**	**0.010**	**0.001**	**0.05**
EQS Grade V	**2.0**	**15**	**10**	**2.0**	**2.0**	**0.4**	**1.0**	**0.100**	**0.001**	**0.1**

Empty cells mean data is not available; * - data for downstream part within Russian territory

Dissolved oxygen (DO) concentration is high enough in almost all rivers of Northeastern China. The Daliao R. is only exception where decrease of DO below EQS for Grade III was observed in 2010 as well as before (NOWPAP POMRAC Technical report #4, 2006).

The water quality of many Chinese rivers is not so good by other parameters. This is especially true in terms of BOD5 , COD and ammonia ions concentrations. By COD_{Mn} the Yangtze and Yalu rivers only are better than Class III, other rivers are more contaminated by organic substances. The same was observed by BOD and ammonia content parameters (Table 23). The Liaohe and Daliaohe rivers are most contaminated by NH_4-N and easy oxidizable organic substances. For the not very polluted rivers like the Yalu and the Yangtze with ammonia (NH_4-) and nitrite (NO_2) concentrations less than 1.0 and 0.05 mgN/l respectively, the nitrate (NO_3^-) prevails among dissolved forms of nitrogen with concentration about 2-3 mgN/l, and TN concentration no more than 3-4 mgN/l. The ammonia form strongly dominates in the polluted rivers like the Liaohe and the Daliaohe (Table 23). The nitrate (NO_3-) concentration decreases down to the 0.3-0.4 mgN/l in such cases.

Oil pollution corresponded to Grade IV was observed in the Liaohe only. The contamination of Chinese rivers by trace metals (Pb, Cd, As) is below the strictest EQS for Grade I waters. Hg is only exception with elevated concentration practically in all rivers (Table 23).

Suspended solids content is not a parameter measured at the routine monitoring by CNEMC Suspended solids (SS) content in the rivers of northeastern China extremely variable from 6.3 mg/l in Luan River to the 520 mg/l in Yangtze and 27000 mg/l in Yellow River (Treatise in Geochemistry, 2003). The significant (five-nine times) seasonal variations of SS due to monsoon floods further complicates the regional assessment of the suspended solids run off.

Chemical composition of the first-class **Japan** rivers facing the NOWPAP sea areas is characterized for the time being by the well oxygenated conditions, low level of averaged turbidity, and BOD5/COD parameters being at the level of less contaminated rivers in China and Korea. Concentration of nutrients (nitrogen and phosphorus) in Japanese rivers do not show significant pollution as well. Only four rivers among 17 have averaged TN more than 1 mg/L, and only Oyabe R. has averaged phosphorus content exceeded 0.1 mg/L. Nevertheless, there is obvious the importance of even such uncontaminated rivers as a source of nutrients and organic matter to the coastal areas. Concentration of potentially toxic metal Pb in the rivers of Japanese west coast does not exceed 0.005 mg/L that is twice less than environmental standard 0.010 mg/L. The application of environmental quality standards in Japan to the unfiltered samples makes possibility of potential pollution by Pb in Japanese rivers much less likely, due to well known affinity of this metal to the suspended forms of

Table 24. Water Quality of the Japanese Rivers that flow into the NOWPAP Region in 2016 (values indicate annual average, mg/L)

Rivers	SS	BOD_5	COD	DO	T-N	T-P	NO_2-N	NO_3-N	Pb	Cd
Teshio River	17	0.5		11	0.49	0.027			<0.005	
Ishikari River	44	0.9	4.8	11	0.9	0.070	0.013	0.58	<0.005	<0.0003
Shiribetsu River	2	0.5	2.2	12	0.64	0.029	0.007	0.49	0.005	0.0003
Iwaki River	15	1.7	3.8	9.9	1.4	0.075	0.044		0.002	<0.001
Yoneshiro River	5	1.2		11	0.68	0.023			<0.005	<0.001
Omono River	8	1.1	2.4	11	0.69	0.037			0.001	0.005
Mogami River	7	2.4	0.7	10.7	0.70	0.029			0.005	0.005
Agano River	4	1.0	2.5	11	*0.59	*0.056				
Shinano River	13	1.2	3.2	9.3	0.92	0.085				
Seki River	25	1.2	3.9	10	1.13	0.073	0.02	0.41	<0.005	<0.001
Jintu River	7	0.7	*2.4	11	0.53	0.032	0.009	0.37	<0.005	<0.0003
Oyabe River	8	2.1	4.4	9.2	1.4	0.105	<0.05	0.77	<0.005	<0.001
Yura River	4	0.7	2.5	9	0.78	0.049	0.01	0.61	<0.005	<0.005
Hii River	6.3	0.5	2.3	10,4	0.48	0.028	0.003	0.34	<0.001	<0.0003
Gono River	3.1	1.0	2.2	10	0.5	0,03	0.01	0.36		
Onga River	6	1.0	2.4	9.2	1.13	0.071	0.020	0.83	<0.001	<0.0003
Matsuura R.	3	0.6	2.6	10.3	0.82	0.050	0.006	0.60		

Note) The blank cells means no data.
Symbol "<" means that the values are under the detection limits which are registered in the government manual.
"*" means that data of 2016 are not available and data of previous report are tentatively cited.

migration. The situation with Cd in Japanese rivers is not so clear, because in the Omono R. and the Mogami R. concentration of Cd reaches up 0.005 mg/L, that exceeds environmental quality standard for protection of human health 0.003 mg/L. The reason of such enrichment has not been studied fully yet. Possible influence of natural or anthropogenic sources of Cd due to weathering or mining and processing of ore deposits at the watersheds could be a reason. At the same time all other rivers of the west coast of Japan are characterized by the very low concentration of Cd (Table 24).

Water quality of major rivers of **Korea** (the Han-, Geum-, Yeoungsan-, Seomjin-, and Nakdong-rivers during 2015-2017 by the set of parameters (DO, COD, BOD, SS, TOC, TN and TP) is presented at Fig.21. and in Table 25. This averaged data are related to the monitoring stations on the down reach of rivers. The result showed that the water qualities varied cross the five rivers and over the past three years, except for DO (Fig. 21). The mean concentration of DO in each river showed little variation ranging between 10 and 11 mg/L, indicating a very good grade for all the rivers. Meantime, the mean BOD and COD varied in locality, for example the mean BOD and COD in the Han River was an average grade (4 mg/L and 7 mg/L, respectively) whereas those in the Nakdong and Seomjin rivers indicated good and very good grades based on the ambient water quality standard. Similarly, the mean of SS, TP and TN in Han River (39 mg/L, 0.2 mg/L, and 7 mg/L) showed relatively greater concentrations compared to those in other four rivers. In case of TOC, the Seomjin River showed the smallest concentration in comparison to other four rivers. The overall water qualities in five rivers were good grade but the result of each criterion varied. Of note, in general, Han

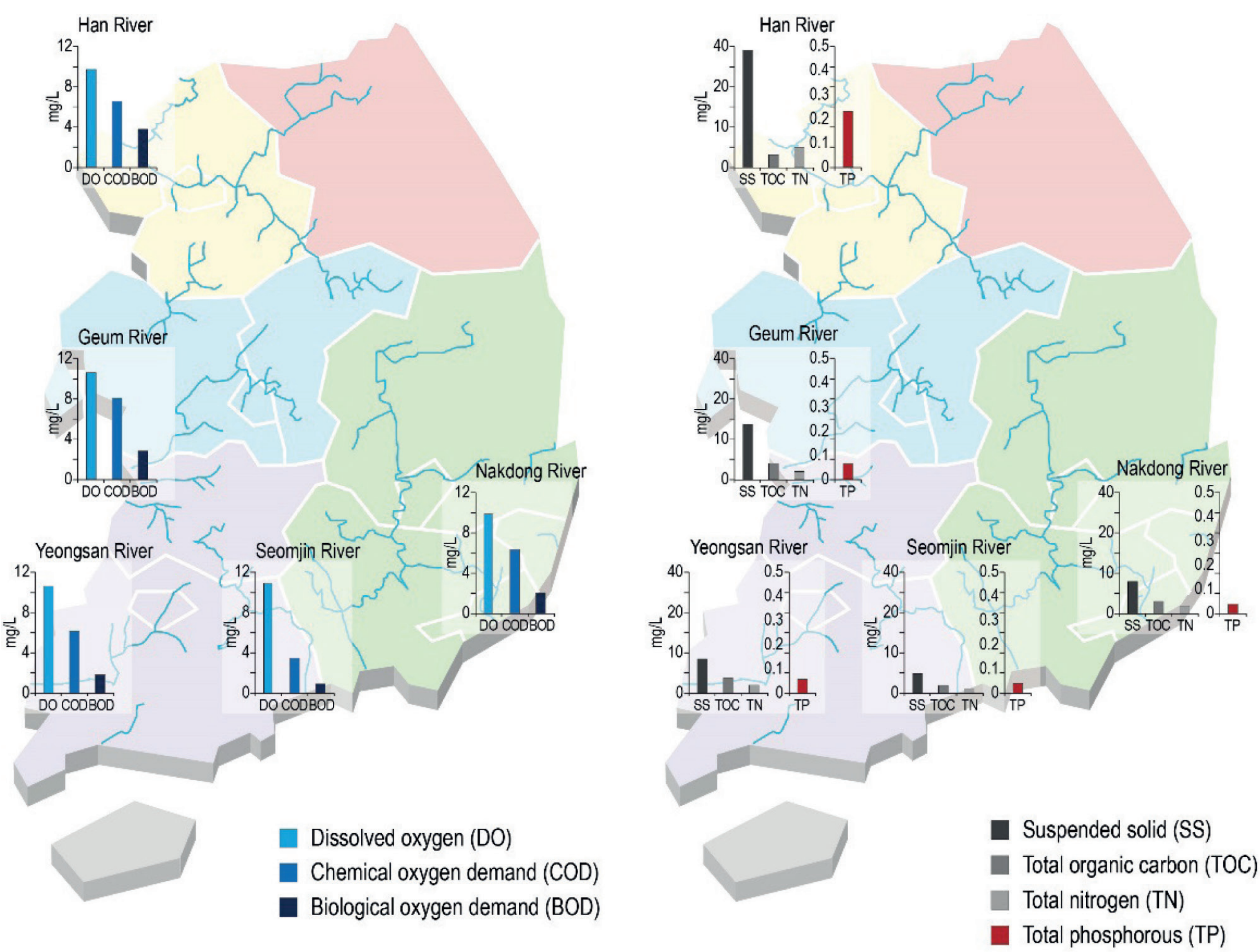


Figure 21. Average concentrations of DO, COD, BOD, SS, TN, TOC and TP in five major rivers of Korea (ROK) from 2015 to 2017.

River showed the greatest nutrient concentrations among other target rivers whereas Seomjin River generally had smaller nutrient concentrations.

Further, looking for the WQI in five major riverine estuaries, the water qualities seemed to improve from 2015 to 2017, indicating good or very good grade at present. In particular, the WQI in the Han River estuary has greatly improved from Grade-III in 2015 to Grade-I (very good) in 2017. Although the WQI showed clear improvement in five major riverine estuaries in Korea, the several water qualities parameters such as SS, TN, and TP indicate that the nutrient input from rivers still affects the water quality of estuary and coastal area.

Table 25. Water quality parameters (mg/l) of Korean rivers (average±std for 2015-2017)

Rivers	SS	COD	BOD	TOC	TN	TP
Han	38.8 ± 39.7	6.56 ± 1.39	3.80 ± 2.09	4.26 ± 1.23	6.72 ± 2.18	0.23 ± 0.13
Geum	17.9 ± 24.2	8.10 ± 2.81	2.82 ± 1.18	5.22 ± 1.79	2.64 ± 1.09	0.06 ± 0.04
Yongsan	11.3 ± 12.3	6.17 ± 1.84	1.82 ± 0.94	5.00 ± 1.45	2.79 ± 0.72	0.06 ± 0.03
Seomjin	6.54 ± 24.1	3.45 ± 1.07	0.90 ± 0.34	2.55 ± 0.85	1.49 ± 0.41	0.04 ± 0.02
Nakdong	11.1 ± 30.3	6.32 ± 0.96	2.01 ± 0.65	4.13 ± 0.75	2.53 ± 0.70	0.04 ± 0.02

Russia. 2015-2017 data on chemical composition and concentration of contaminants in the river water of Primorskii Krai obtained by the state Environmental Monitoring Center (EMC) of ROSHYDROMET Primorskii Territorial Office combined with some data from research works of the Pacific Geographical Institute and Pacific Oceanological Insitute of Far Eastern Branch of the Russian Academy of Sciences are presented in Table 26. The data were observed on the freshwater stations closest to the seacoast.

Table 26. Chemical composition (mg/l) of typical rivers in Russia related with the NOWPAP sea areas (range of annually averaged data for 2015-2017 period)

Rivers	COD	BOD	DIP	NO_3-N	NO_2-N	NH_4-N	Fe	Mn
Tumen*	3.0-3.5**	-	0.02-0.04	1.2-1.4	0.01-**0.04**	0.03-0.05	0.02-0.16	0.003-0.060
Razdolnaya	20.9-33.5	1.51-1.56	0.01-**0.07**	0.79-1.28	0.02-**0.04**	**0.54-0.74**	**0.46-0.47**	0.044-0.069
Knevichanka	37.3-42.8	5.11-8.20	**0.14-0.26**	0.88-1.72	**0.053-0.078**	**3.3-4.86**	-	-
Tumnin*	3,2-4,0**	-	0,001-0,007	0,02-0,08	0,001-0,0014	0,006-0,019	0,05-0,14	0,003-0,005
Ussury (upstream)	16.0-29.9	0.43-1.44	0.01	0.09-0.26	0.005-0.01	0.15-0.41	**0.59**	0.008
Ussury (downstream)	19.8-25.1	3.48-3.87	-	0.25-0.42	0.013-0.015	**0.92-1.13**	**0.47-0.69**	-
Susuya	12.7-14.6	2.81-3.82	-	0.44-0.75	0.014-**0.028**	**0.70-1.0**	**0.16-0.27**	0.015-0.062
MPC-f[1]	**15**	**2**	**0.05**	**9.1**	**0.02**	**0.4**	**0.1**	**0.01**
MPC-p[2]	**5**	**nd**	**nd**	**10**	**0.8**	**1**	**0.3**	**0.10**

*- data from research activities of PGI and POI FEBRAS, others – from Annual reports of ROSHYDROMET; ** - data on DOC; [1] – MPC for the freshwater for fishery purpose; [2] – MPC for the freshwater for public use including drinking; parameters exceeding MPC are marked by bold

The network of hydrochemical observations in the region are uneven. A number of rather large rivers in the unpopulated north coast of Primorskii Krai and south part of Khabarovskii Krai, including the Samarga, Koppi, and Botchi rivers are not described with respect to contaminant concentrations. Very few regular data are available on the water quality of rivers of Sakhalin Is. The Susuya R. inputting to the Aniva Bay (south Sakhalin) and drained Yuzhno-Sakhalinsk, the biggest city at the island is the only river with regular data on the chemical composition.

Dissolved oxygen (DO) and pH of water of practically all Russian rivers within NOWPAP region do not indicate any deterioration in water quality, and since is not presented in Table 26. The near bottom waters of the stratified eutrophic estuaries is the only exception. For example in the Razdolanya and Tumen rivers estuaries DO can temporally drops down to 2-4 mg/l in warm seasons at the elevated phytoplankton production and diminished river discharge. (Tishchenko et al., 2014, Shulkin et al., 2016).

BOD values exceed MPC 2 mg/l in rivers draining moderately populated and economically developed watersheds, namely in the Razdolnaya and the Knevichanka (the tributary of Arteomovka R.). The enlarged COD was also observed in the Razdolnaya and Knevichanka rivers where clear pollution by BOD took place. At the same time COD parameter in many Russian rivers is significantly higher than in the Japanese and Korean rivers. The use of stronger oxidant $K_2Cr_2O_7$ for the determination of COD in Russia is the first reason. Moreover, even uncontaminated rivers, draining the forest landscapes of the Russian Far East, are rich in natural dissolved organic substances which can be oxidized and give the elevated COD. That is in Russia COD parameter should be used as an anthropogenic press indicator with caution. BOD level is more unambiguous indicator of pollution by wastewaters, and the increased BOD in the downstream of the Ussury R. compare with the upstream along with constant COD clearly support it (Table 26). NH_4 and NO_2 as well as PO_4 ions (DIP) in the river water are equal or exceed the strictest MPC for fishery water bodies in the most anthropogenically loaded Razdolnaya, Knevichanka rivers and downstream of Ussury R.. At the same time less stricter MPC for communal use is exceeded for NH_4 only, and water quality of the Razdolnaya R. on NH_4 by this MPC can be assessed as satisfactory (Table 26). Downstream of the Tumen R. in China, NH_4 content is also elevated (Table 23), but near the Tumen R. mouth in Russia NH_4 decreases while NO_3 increase reflecting high ability of Tumen R. to self-purification by nitrification.

Another natural peculiarity of many rivers of Russia within NOWPAP region is elevated level of dissolved Fe, and sometimes Mn. Concentration of dissolved Fe exceed both MPC for fishery water bodies and for public/drinking use (Table 26). Dissolved Mn exceeds the strictest MPC for fishery water bodies only. The large portion of forested areas and wetlands on the watersheds, high enough atmospheric precipitation prevailing evapotranspiration, and long enough water residence time in rivers are the major natural factors providing the elevated level of dissolved Fe in the rivers of Russian Far East. The increased concentration of dissolved Mn is connected first of all with abundaqnce of wetlands reduced soils on the watersheds.

The use of trace metal other than Fe and Mn for water quality assessment as part of routine monitoring procedures in Russia meets with the same problems as encountered in other countries (for example, MAP MTS #141, 2003). The main reasons are analytical problems in obtaining reliable “contamination-free” results, and the need to use filtered samples for analysis given an affinity of most metals to suspended particles. The uncertainties connected with existence of significant part of many metals (Fe, Al, REE and others) in river waters as colloids is an additional problem. Analytical monitoring procedures in China, Japan and Korea are, as a rule, carried out with unfiltered samples.

At the same time, the potential efficacy of metal concentrations in rivers as indicator of the anthropogenic influence on the surface waters is obvious.

Existing reliable data on dissolved forms of some metals in Russian rivers within the NOWPAP region are presented in Table 27. These data have been borrowed from the published scientific research of PGI and FEGI FEBRAS (Shulkin et al., 2007, Shulkin et al., 2009, Chudaeva et al., 2011).

Table 27. Concentration (μg/l) of dissolved forms (<0.45 mkm) of metals in rivers flowing into the NOWPAP sea area from Russia

	Fe	Mn	Zn	Cu	Pb	Cd	Ni
Tumen	60.7	97.7	0.93	1.57	0.166	0.022	0.72
Razdolnaya	70.4	31.4	0.56	1.05	0.047	0.008	0.91
Knevichanka	44	10	0.7	0.75	0.19	0.014	0.61
Rudnaya	21	110	**120**	**1.35**	0.64	0.25	0.8
Zerkalnaya	14.7	2.5	1.54	0.32	0.039	0.008	0.1
Tumnin	55	5	1.08	0.23	0.07	0.004	0.34
Ussury	131	31	0.74	0.68	0.054	0.005	0.50
MPC	**100**	**10**	**10**	**1**	**6**	**5**	**10**

The concentrations of the most potentially hazardous dissolved forms for heavy metals Cd and Pb are far below MPC as well as for Zn and Ni. The only exception is the specifically polluted Rudnaya River that drains a watershed with lengthy developed mining and ore dressing activity. Dissolved Cu concentration exceeds MPC 1 μg/l (0.001 mg/l) in many rivers, but is explained by unsupportable low MPC established for exclusively ionic dissolved forms of Cu, though in natural water the major part of dissolved Cu is presented by less toxic organic complexes.

According to the previous review (POMRAC Technical Report # 7, 2009) phenols and oil (petroleum hydrocarbons – PHC) concentrations exceed MPC in the most anthropogenically influenced Russian rivers, though MPC for phenols is nearly equal to MDL and improvement of the method used for the determination of phenol is needed. The situation for the time being continue to be the same.

At the assessment of river waters quality in relation to the MPC (EQS) by the averaged concentration of chemical substances (Table 26) it is necessary to take into account significant seasonal variability of the chemical composition of river waters.

Besides fresh water quality there is an issue related with a riverine input (flux) of contaminants, and river influence on the marine environment. The assessment of river fluxes is necessary at comparison the natural background fluxes with anthropogenic wastewaters, sewages and exhausts generation and release. These negative consequences of human activities are expressed as fluxes usually (mass per time unit).

The first proxy of river fluxes to the sea can be assessed by multiplication of water runoff (Table 1) by the chemical substance concentrations (Table 23, 24, 25, 26). Such estimates for chemical parameters broadly used as water quality indices are presented in Table 28, 29, 30, 31 for the NOWPAP countries based on the last available water quality assessment (2010-2012 for China, 2015-2017 for Korea and Russia, 2016 for Japan).

At the discussion of the riverine inputs of contaminants presented in Tables 28-31 it is necessary to take into account the limitations of such evaluations. The first one, is related with restricted number of rivers studied in terms of water discharge, and even less studied in terms of water quality. Korea and Japan are in better position, but in China and especially in Russia the accounted river runoff with regularly analyzed chemical composition do not exceed 20-50% of overall runoff. The second uncertainty is connected with significant seasonal and notable inter-annual variability of water discharge and chemical composition of river waters. For example two times inter annual difference between suspended solids, organic matter and nutrients runoff by major Korean rivers (Table 30) can be explained by the variability of water discharge only. Moreover, temporal variability of runoff depends on the landscape structure of watersheds, and anthropogenic press. All these factors make regional assessment of river inputs of contaminants rather difficult task. Nevertheless, such valuations give important information about relationship between river inputs and fluxes of contaminants connected with the generation and disposal of wastewaters, and other wastes.

Table 28. Annual runoff of water (km^3) and some chemical substances (tons/year) in major Chinese rivers related to the NOWPAP region (data for 2010)

Rivers	Water	COD_{Mn}	NH_3-N	Oils	TN	TP	phenol	Hg	Pb
Yangtze	1034	2585000	434280	29986	1623000	173000	2791.8	10340	9306
Dalinghe	0,41	3649	390	8.6	-	-	1.4	32.8	2.1
Daliaohe	14,8	118400	21460	340.4	31400	1300	14.8	296	74
Tumen	6,8	93840	2380	115.6	-	-	19.0	204	13.6
Yalu	38,4	99840	6528	960	39800	1000	38.4	768	192

means no data

Table 29. Annual runoff of water (km^3) and some chemical substances (tons/year) in some rivers of Japan related to the NOWPAP region (data for 2016)

	Rivers	Runoff, km3/y	BOD	COD	SS	T-N	T-P
1	Teshio river	8,20	4,102		139,468	4,020	221
3	Ishikari river	19,48	17,536	93,523	857,296	17,536	1,364
4	Shiribetsu river	2,09	1,047	4,605	4,187	1,340	61
6	Iwaki river	2,06	3,506	7,837	30,936	2,887	155
7	Yonesiro river	6,20	7,436		30,983	4,214	143
8	Omono river	7,24	7,967	17,384	57,945	4,998	268
10	Mogami river	16,34	39,226	11,441	114,408	11,441	474
13	Agano river	10,29	10,289	25,719	41,150	6,070	576
14	Shinano river	13,67	16,412	43,765	177,797	12,583	1,163
15	Seki river	1,31	1,576	4,859	32,833	1,484	96
19	Jintu river	5,74	4,022	13,788	40,215	3,045	184
21	Oyabe river	3,39	3,695	7,741	14,072	2,463	185
26	Yura river	1,78	1,249	4,459	7,134	1,391	87
31	Hii river	1,17	587	2,700	7,396	563	33
32	Gono river	5,98	5,982	13,161	18,545	2,911	179
12	Onga R.	1,27	1,275	3,969	7,649	1,440	91
11	Matsuura R.	0,60	360	1,558	1,798	491	30
Total for 17 rivers		105,2	126,267	256,609	1,583,812	78,877	5,310
Nominally Total for 35 first class rivers		4,062	147,874	289,621	1,856,769	87,813	5,704

Table 30. Annual runoff of water (km³) and some chemical substances (tons/year) in major Korean rivers related to the NOWPAP region (data for 2015-2016)

Rivers		Water	SS	COD	BOD	TN	TP
Han	2015	12,48	484224	81869	47424	83866	2870
	2016	19,81	768628	129954	75278	133123	4556
Geum	2015	2,86	51194	23166	8065	7550	172
	2016	5,62	100598	45522	15848	14837	337
Yongsan	2015	1,29	14577	7959	2348	3599	77
	2016	2,37	26781	14623	4313	6612	142
Seomjin	2015	2,43	15892	8384	2187	3621	97
	2016	3,96	25898	13662	3564	5900	158
Nakdong	2015	7,49	83139	47337	15055	18950	300
	2016	14,76	163836	93283	29668	37343	590

Table 31. Annual runoff of water (km³) and some chemical substances (tons/year) in some Russian rivers related to the NOWPAP region (averaged data for 2015-2017)

Rivers	Water	COD	BOD	DIP	NO_3	NO_2	NH_4	Fe	Mn
Tumen	6,78	21696	-	203	8814	203	271	610	210
Razdolnaya	4,75	131575	7315	181	4560	138	2898	2185	261
Knevichanka	1,03	41715	7354	216	1370	63,9	3935	-	-
Tumnin	7,95	28620	-	31,8	398	7,95	95,4	875	32
Ussury	10,15	228375	6699	102	1624	71,1	2639	5989	812
Susuya	0,9	12510	3033	0	504	23,4	801	189	31

means no data

7. Temporal trends in river water quality

The water quality from 2006 to 2016 in the biggest in **China** Yangtze R. inflowing to the NOWPAP sea area shows somewhat consistency (Fig. 22) with low concentration of all contaminants. The same stable status was observed for the Yangtze R. during the previous 2001-2005 period (POMRAC Technical Report # 7, 2009). Another big river of northeastern China – the Yalu R. show the same low and stable level of contaminants similar to Yangtze R. (Fig. 23). The more polluted by organic substances (COD and BOD) and petroleum hydrocarbons (PHC) Tumen R. shows clear decrease of these components during the last decade, though the COD/BOD level in 2008 and after that continued to be 2-3 times more in the Tumen R. compare with the Yangtze and the Yalu rivers.. There was some improvement of water quality after 2008 in terms of BOD and PHC contents in the Dailaohe R. draining watershed with developed industry in Liaoning province (Fig. 23). But present level of BOD in the Daliaohe R. is twice more than in Tumen R. Moreover COD in the Daliaohe R. continues to be permanently high, as well as NH_4^- concentration exceeding the EQS IV grade (1.5 mg/L).

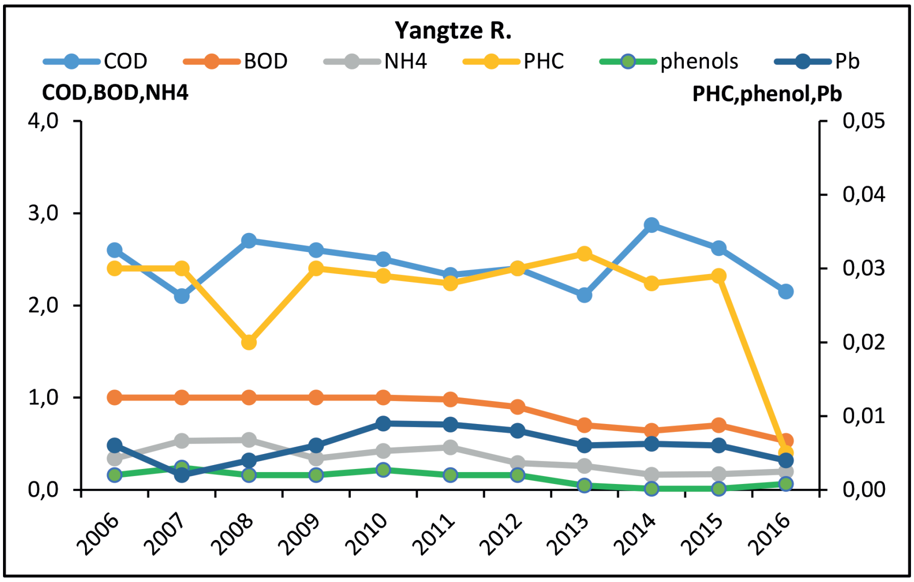


Figure 22. Inter-annual variation of water quality of Yangtze R. for 2006-2010

The Dalinghe R. the most polluted one among the presented rivers with COD 200 mg/L, BOD 100 mg/L, and PHC 0.4 mg/L in 2006 also showed significant improvement since 2006 to 2010 (Fig. 23).

Thus, based on the national reports notable progress can be postulated by 2016 in the river water quality in the northeastern provinces of China. It is especially true for the moderately and heavily

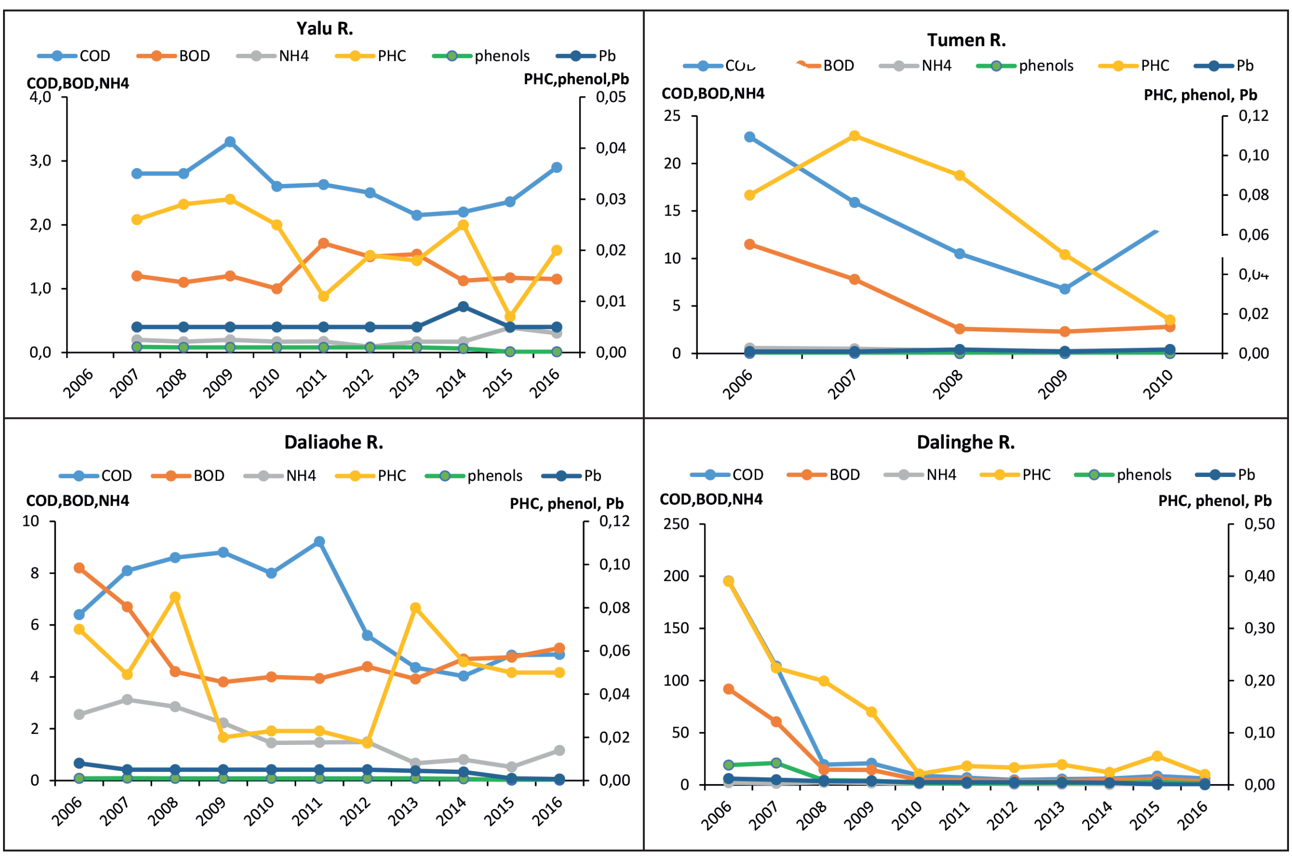


Figure 23. Inter-annual variation of water quality of the typical rivers of northeastern China with the different level of pollution.

polluted rivers. Unfortunately, no data on the river water quality are available for the period after 2010.

As an overview of temporal trends in river water quality, BOD of river water in the **Japan** regions facing NOWPAP area since 2005 through 2016 is almost stable and no clear increasing or decreasing trend was observed. The range of BOD values during the time is as follows:

The Ishikari River at Ishikari- Ohashi: 0.8~0.9 mg/L

The Mogami River at Ryobane Bashi : 0.7~0.9

The Shinano River at Heisei-Ohashi : 1.0~1.4

The Jintsu River at Ogiura-Bashi : 0.7~1.4

The Gono River at Gohnokawa-Bashi : 0.5~0.7

Data source: Chronological Time Tables 2019-2010 (2018)

A general trend of BOD that the value is almost stable and does not show any clear increasing or decreasing trend, is much the same in cases of COD, TN, TP and SS. It means that inter annual variations of river input of substances will depend on the water discharge variability mainly. Estimated pollutant load from rivers to the NOWPAP region in 2016 for BOD, COD, TN and TP was 148,000, 290,000, 87,800 and 5,700 tons/year, respectively. Comparing these estimated data with those of the same parameters in 2006, the present estimated load of COD, TN and TP is much the same as in 2006 although load of COD, TN and TP slightly decreased and load of BOD a little increased.

The temporal trends of riverine water quality in the major **Korean** rivers (the Han-, Geum-, Yeoungsan-, Seomjin-, and Nakdong- rivers) are presented by example of TN, TP, COD, and BOD from 2007 to 2017 (Fig. 24, 25, 26 and 27) along with inter annual variability of 50% water discharge (Fig. 28) . The data were obtained at the last monitoring station on the down reach of the river. The concentration of TN in the Seomjin R. and the Nakdong R. has remained steady below 5 mg/L over

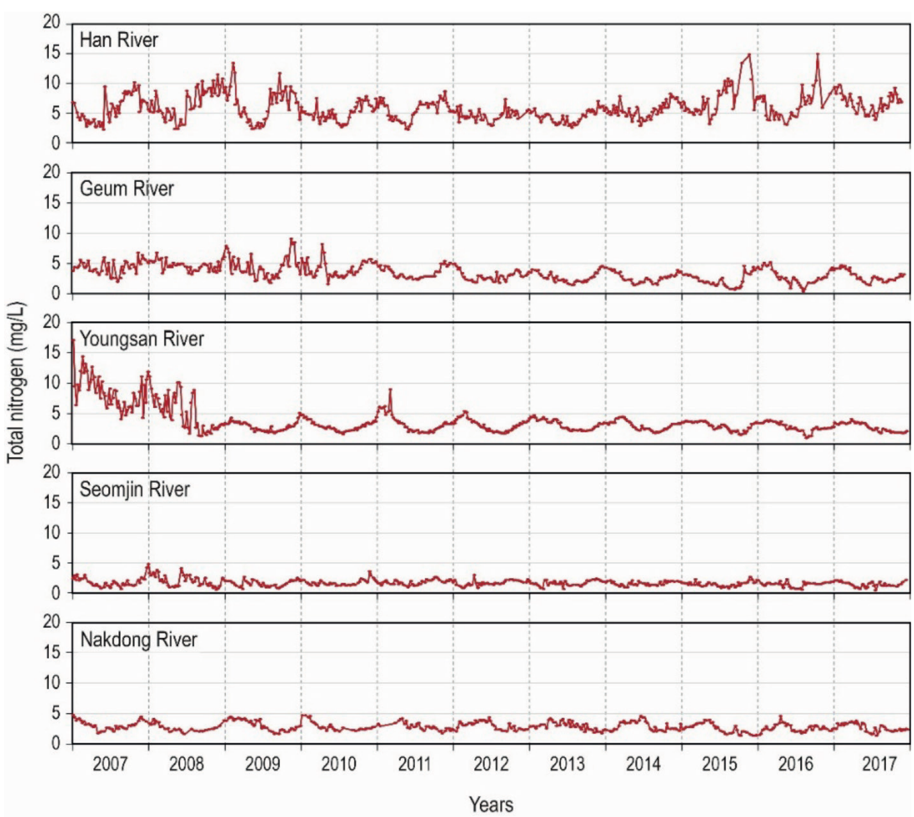


Figure 24. Temporal concentrations of Total Nitrogen (TN) in five major rivers in Korea from 2007 to 2017.

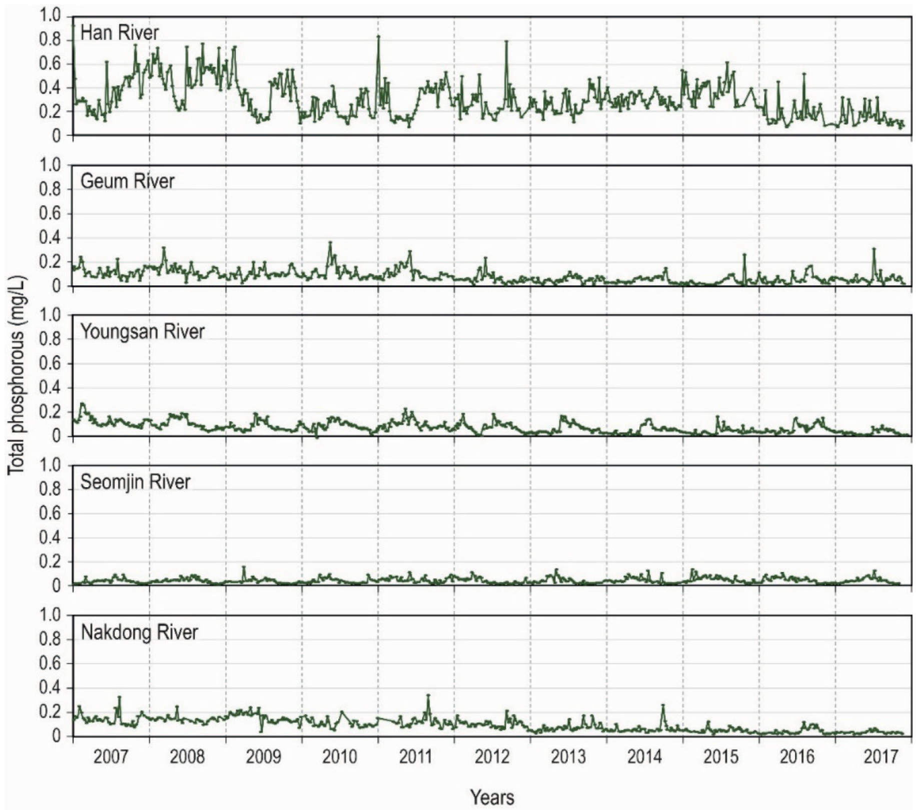


Figure 25. Temporal concentrations of Total Phosphorous (TP) in five major rivers in Korea from 2007 to 2017.

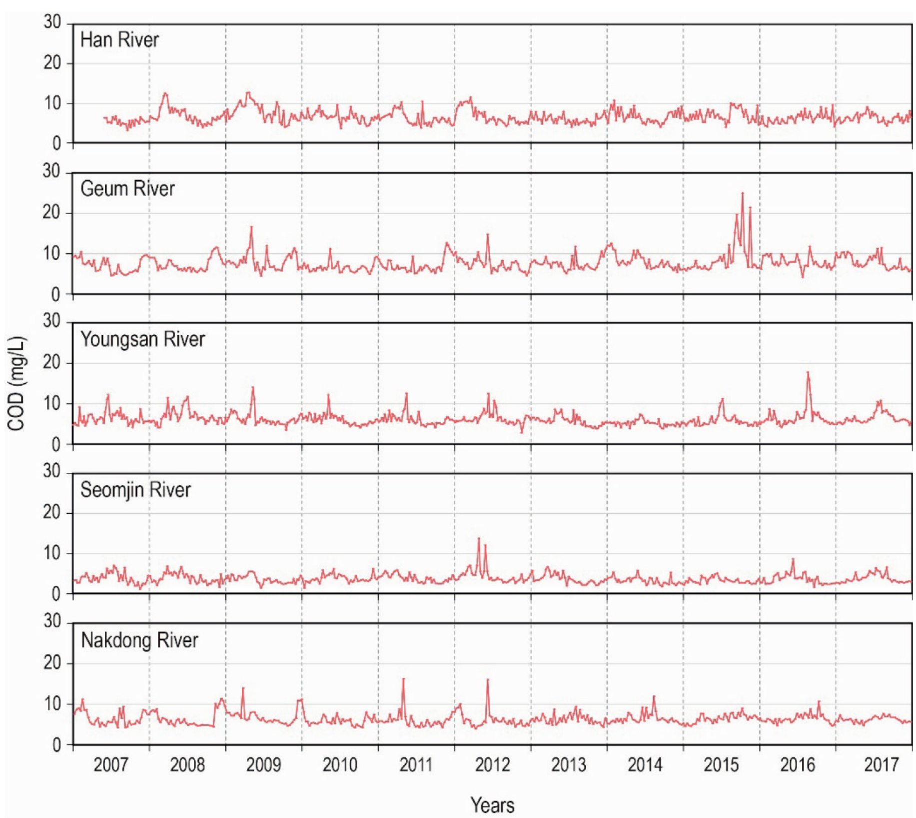


Figure 26. Temporal concentrations of chemical oxygen demand (COD) in five major rivers in Korea from 2007 to 2017.

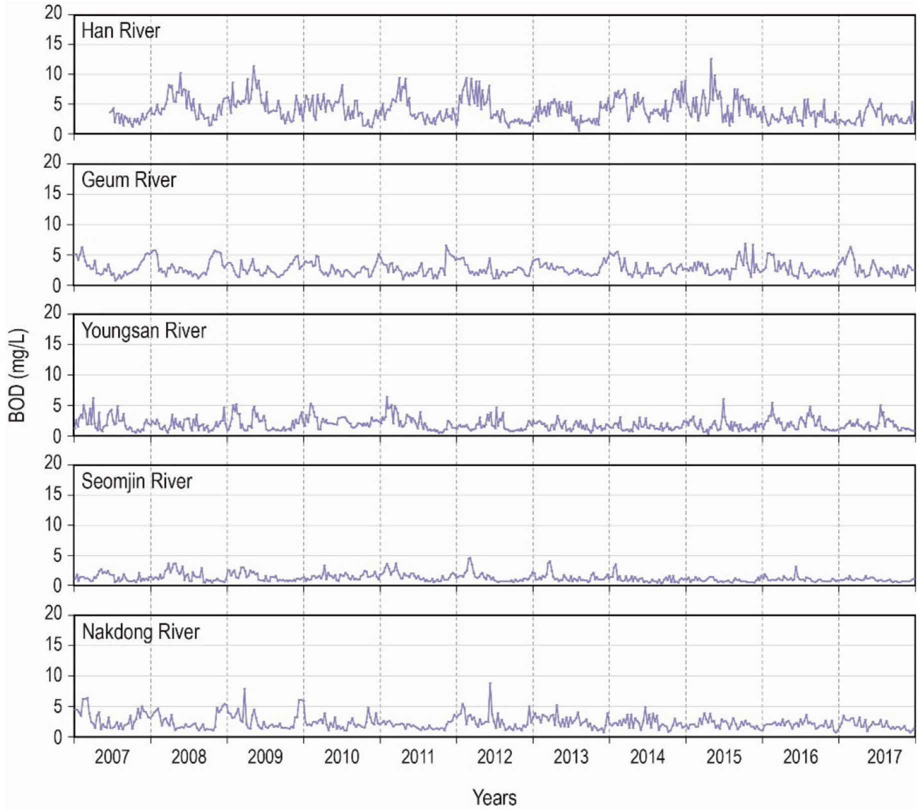


Figure 27. Temporal concentrations of biochemical oxygen demand (BOD) in five major rivers in Korea from 2007 to 2017.

the past 10 years. In the Youngsan R., the concentration of TN dramatically fluctuated between 2 to 15 mg/L from 2007 to 2008 and has shown relatively constant temporal trend from 2009 to 2017. The reason of a high fluctuation of TN in the Youngsan R. between 2007 and 2008 might be due to the national scale dredge and construction of dikes in major rivers of Korea. The concentration of TN in the Geum R. has shown a decreasing trend from 2007 to 2017. In the Han R., the concentration of TN was relatively greater than those in other rivers (between 5 to 15 mg/L) and has indicated the largest fluctuation among other rivers over the past 10 years.

TP in the Han R. has also shown larger fluctuation between 0.2 to 0.8 over the past 10 years in comparison with other rivers (Fig. 25). Four major rivers apart from Seomjin R. indicated relatively wide variations and greater concentrations of TP in 2007 and 2008. This wide fluctuation of TP concentration could be due to the large scale dikes construction works. The concentrations of TP in the Geum, Yeoungsan, Seomjin, and Nakdong rivers have remained constant below the 0.4 mg/L. The decreasing TN and TP in five major rivers could be the result of effective management and operation of national water quality monitoring system, TWPLMS in Korea after 2010.

COD in the Han and Seomjin rivers were relatively consistent with concentrations of 10 mg/L over the past 10 years. In the Geum, Yeoungsan, and Nakdong rivers COD were generally greater than those observed in other rivers (between 5 to 15 mg/L). Especially, the concentrations of COD in the Geum R. dramatically fluctuated between 5 to 25 mg/L in 2015, reflecting a dynamic water column condition due to irregular freshwater discharge through the gate. The elevated COD in three rivers might also be related to the freshwater derived contamination in the closed estuarine system (the Geum R., the Yeoungsan R., and the Nakdong R.).

BOD in the Seomjin R. has shown relatively small concentrations below 5 mg/L over the past 10 years compared to those in other rivers. The concentrations of BOD in the Geum, Yeoungsan, and Nakdong rivers were relatively consistent below 10 mg/L. In the Han River, contrast to COD, BOD

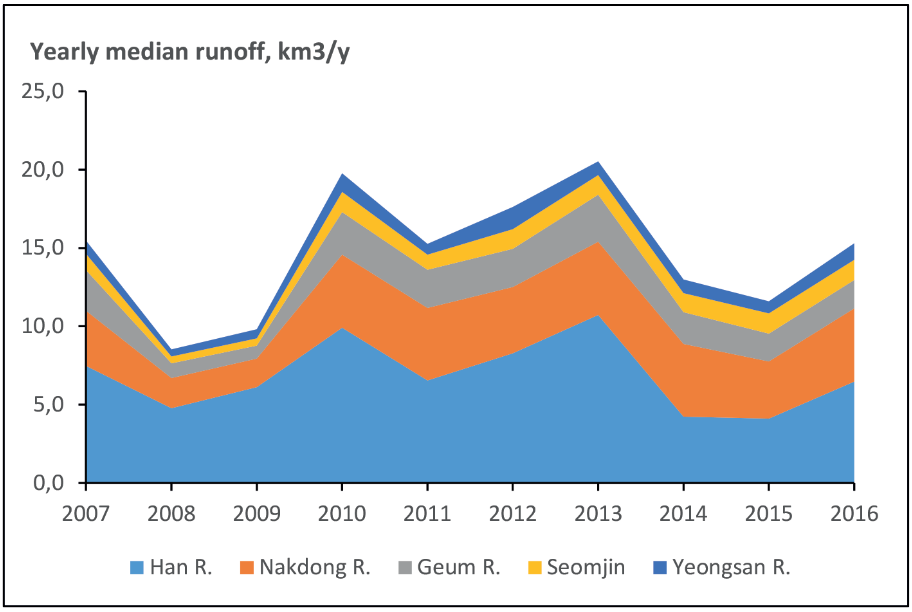


Figure 28. Inter annual variability of the yearly median runoff of the major Korean rivers during last decade (Source: http://www. wamis.go.kr).

has shown greater fluctuation between 2 to 13 mg/L over the past 10 years, but it would be noteworthy that BOD values were fairly stable in 2016 and 2017 with < 6 mg/L. Overall, the water qualities in five major rivers were gradually improved over the past 10 years.

Looking at the WQI in major riverine estuaries, the water qualities seemed to improve from 2015 to 2017, indicating good or very good grade at present (Table 32). In particular, the WQI in the Han River estuary has greatly improved from Grade-III in 2015 to Grade-I (very good) in 2017.

Table 32. Water Quality Index (WQI) of major riverine estuaries in Korea

Region	Year	WQI	Grade
Han River	2015	34	III
	2016	29	II
	2017	23	I
Geum River	2015	32	II
	2016	32	II
	2017	29	II
Yeongsan River	2015	35	III
	2016	34	III
	2017	20	I
Seomjin River	2015	33	II
	2016	30	II
	2017	23	I
Nakdong River	2015	28	II
	2016	28	II
	2017	26	II

The inter annual change of chemical composition of **Russian** rivers within the NOWPAP area is different for different parameters (Fig. 29, 30). The high COD values in the Russian rivers com-

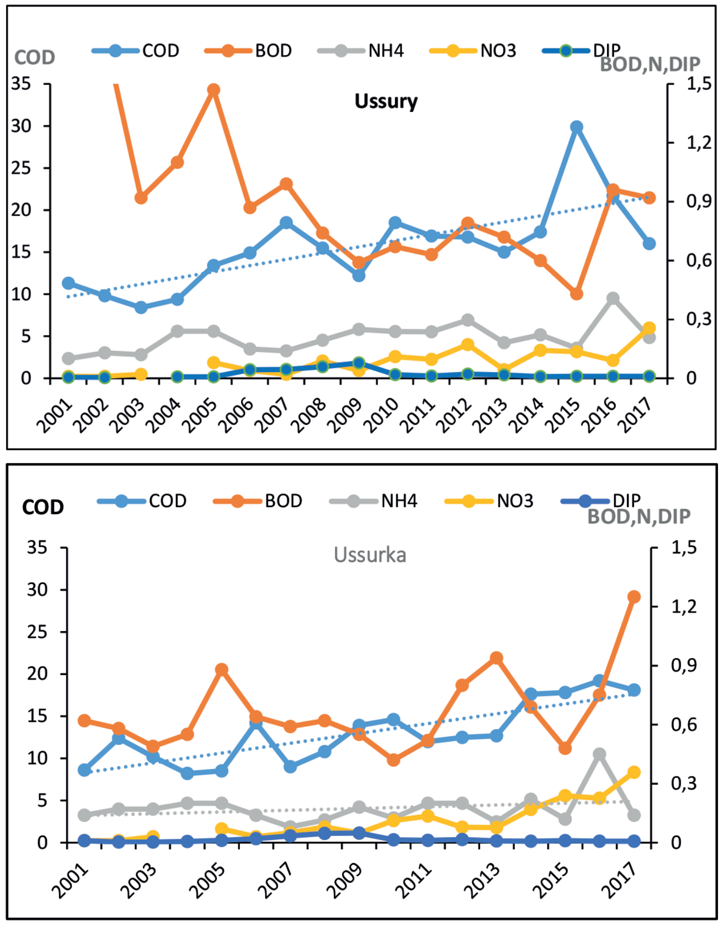


Figure 29. Inter-annual variation of water quality parameters (mg/L) in the clean rivers of Russian part of the NOWPAP region

pare with lower COD in the rivers of other NOWPAP countries (Fig. 26 and Fig. 29) are explained by the use in Russia stronger oxidative at the COD determination. In rather clean Russian rivers COD varies 10-25 mg/L, increasing to 25-35 mg/L in the moderately contaminated Razdolnaya R. and to 35-50 mg/L in the heavily polluted Knevichanka R. (Fig. 29, 30). A notable increase trend of COD was observed during 2001-2017 period, especially in the big clean rivers (Fig. 30). The BOD in the clean Russian rivers 0.6-1.0 mg/L is similar to the clean Chinese rivers (Yangtze or Yalu). BOD parameter is sensitive to the wastewaters treatment, and shows distinct decrease from 15-25 mg/L to 1.5-2 mg/L in the rather polluted Razdolnaya River after construction of WWTP in 2004. Another polluted stream without proper treatment facilities – the Knevichanka River has continuously elevated BOD level 6-10 mg/L the last two decades (Fig. 30).

Concentration of NH_4 in rather pristine Russian rivers varies around 0.2-0.3 mgN/L similar to the clean Chinese rivers, but with slight increase trend (Fig. 29). In the moderately contaminated rivers like the Razdolnaya R. NH_4 concentration elevates to 0.5-0.7 mgN/L, and in the heavily polluted ones like the Knevichanka R. up to 2-5 mgN/L with clear worsening of the situation during the last decade (Fig. 30). Clear increase trend is

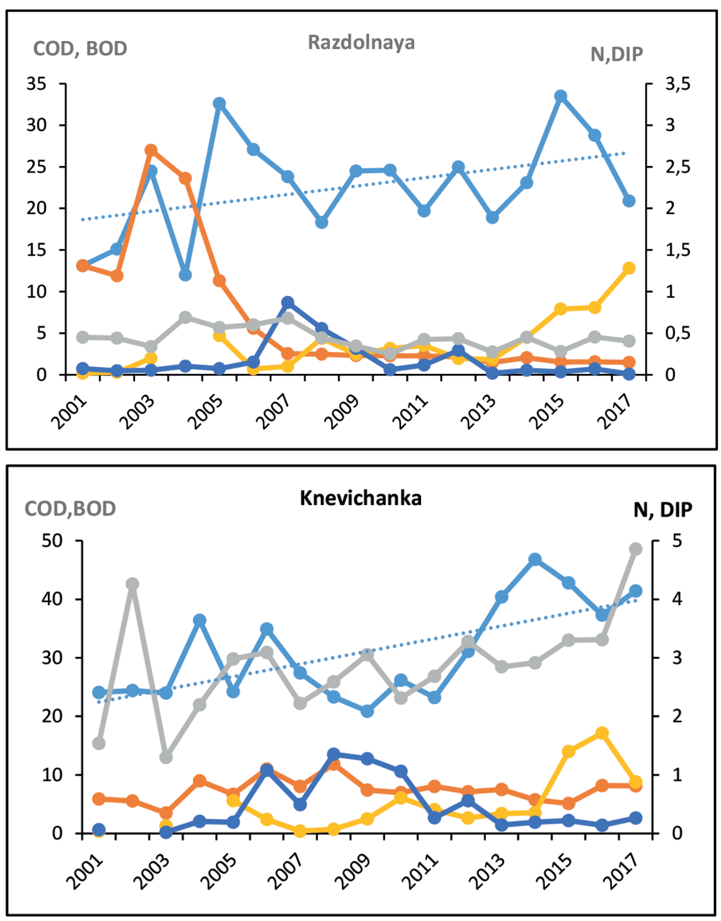


Figure 30. Inter-annual variation of water quality parameters (mg/L) in the moderately contaminated (the Razdolnaya R.) and heavily polluted (the Knevichanka R.) rivers of the Russian part of the NOWPAP region

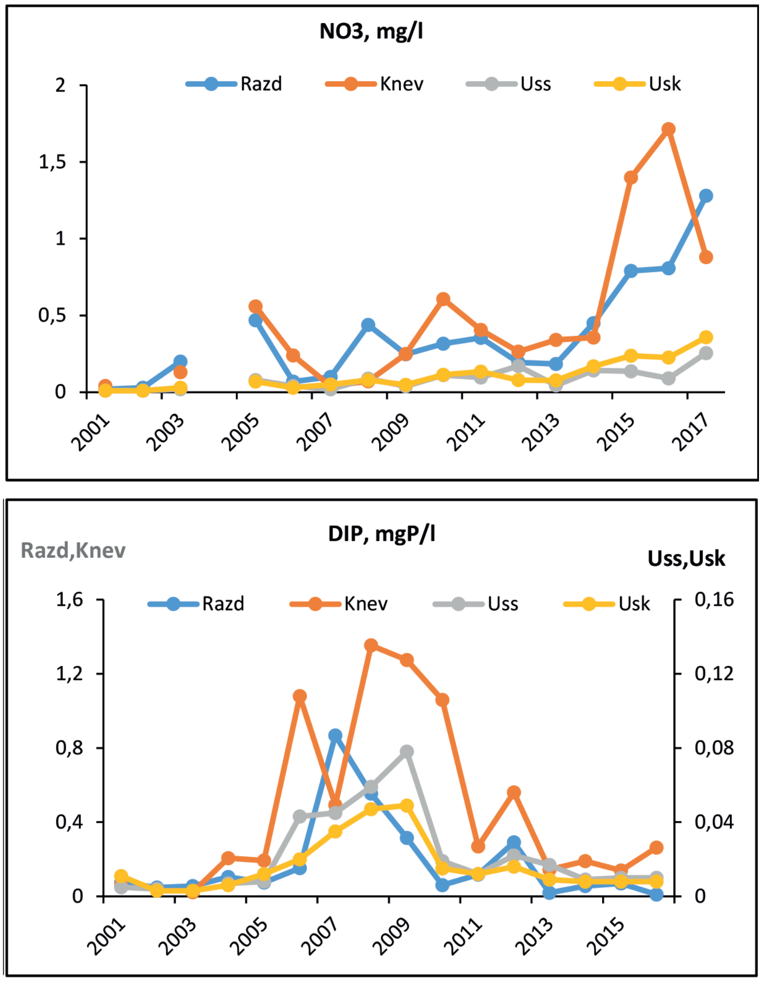


Figure 31. Inter-annual trends in nitrate and phosphate concentrations in the Russian rivers with different anthropogenic load within NOWPAP region

observed for the nitrates concentration in the all Russian rivers during last decade. In the clean rivers like the Ussury and the Ussurka annually averaged concentration of nitrates grows from 0.02-0.05 to 0.12-0.36 mgN/L. The moderately contaminated Razdolnaya R. shows the growth from 0.1-0.6 to 0.8-1.3 mgN/L, and even in the seriously polluted Knevichanka R. nitrates concentration increased from 0.2-0.5 to 0.9-1.7 mgN/L during the last decade (Fig. 30).

Phosphate level was quite low (0.01-0.02 mgP/L) in the uncontaminated rivers of Russia within the NOWPAP region before 2005 and after 2010, but during 2006-2009 period notable growth up to 0.05-0.08 took place (Fig. 29). Similar period of elevated concentration of phosphates in 2006-2009 was observed for the contaminated rivers, but the scale of inter annual increase was much higher: from 0.1-0.2 mg/L before 2005 and after 2010, and 0.5-1.4 mg/L during 2006-2009 (Fig. 30).

Thus, inter-annual changes of water quality in the Russian rivers within the NOWPAP region is somehow contradictory. From one side the upgrading of wastewaters treatment is accompanied by clear decrease of contamination by organic substances, reflecting in BOD decline. From other side there are some signs of the growth of anthropogenic load on the rivers. Increase trend of COD level in rather clean rivers (Fig. 29) is one sign. More pronounced inter-annual upsurge of nitrates takes place in the relatively clean rivers and in the contaminated ones as well though with different scale (Fig. 31).

Increase trend of nitrates in river waters is coincided with the growth of fertilizers usage (Fig. 31). The matching in the dynamic of these two parameters has causative nature probably. The coincidence of the dynamic of fertilizers usage on watersheds and following increase of nitrates concentration in the draining rivers was observed in other region, e.g. for the Yangtze R. (Zhang et al., 1999).

The inter-annual trend of annually averaged phosphate concentration is also similar to the Russian rivers within the NOWPAP region (Fig. 31), but the reason of the elevated level of phosphates in 2006-2010 with the following decline is not obvious, and an additional research is needed.

8. Assessment of direct inputs of contaminants during last decade

The total volume of wastewaters directly inputted from three northeastern Chinese provinces to the NOWPAP sea areas shows more or less graduate increase from 0.89 billion tons (~0.89 km^3) in 2006 to 1.28 billion tons (~1.28 km^3) in 2016 (Fig. 32). At the same time the direct input of organic matter, reflected in COD, and ammonia nitrogen demonstrate clear decrease trend especially during 2006-2014 period. This fact reflects obvious successful efforts of Chinese governments on the proper treatment of direct wastewater discharges, though in 2015-2016 the growth of COD and ammonia nitrogen was observed (Fig. 32). The amount of PHC and TP, delivered to the NOWPAP sea areas by direct inputs, also shows decrease trend during the last decade.

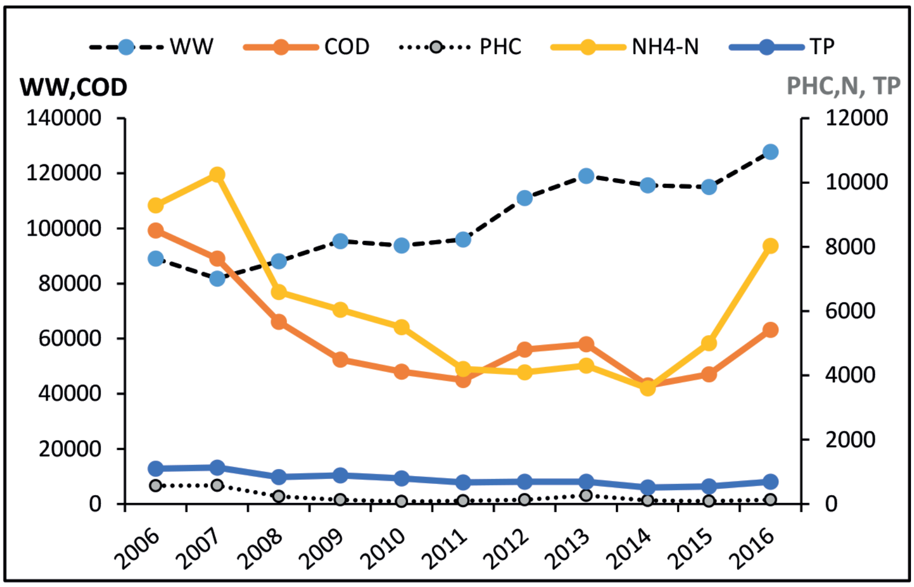


Figure 32. The annual amount of wastewaters (WW, *10 thousand tons), COD, PHC, NH_4-N, TP (tons) delivered from three northeastern Chinese provinces to the sea by direct inputs during the last decade.

The quota of different provinces to the amount of wastewaters transported to the NOWPAP sea areas as direct inputs, demonstrates the prevalence of Liaoning province in 2006 and graduate increase of the inputs from Shandong province since that (Fig. 33).

The quota of Jiangsu province in the direct inputs of wastewaters continues to be very minor – less than 5% in terms of amount of wastewaters volume, and even less 2.6% in terms of amount of ammonia nitrogen and phosphorus delivered by direct inputs. Taking into account much higher quota of Jiangsu province in terms of population and GDP (Fig. 3) it reflects the character of industrial specialization of different Chinese provinces. It should be noted that the increase of direct input of COD and especially ammonia nitrogen in 2015-2016 (Fig. 32) is provided by the influence of discharges from Liaoning province (Fig. 33).

Beside contaminants connected with organic matter (COD and NH_4-N) direct inputs are responsible for the delivery of other substances namely trace metals with an annual direct input about

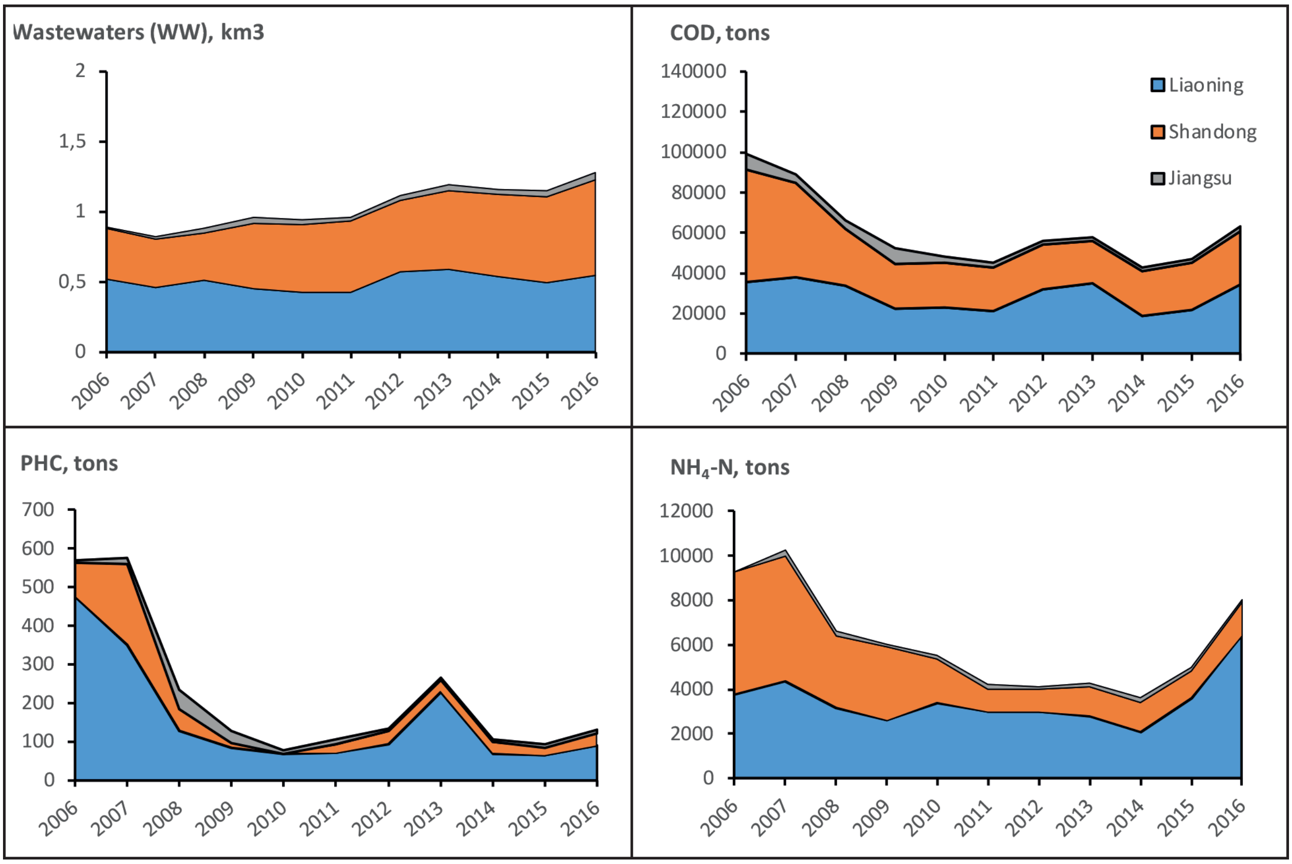


Figure 33. The quota of three northeastern Chinese provinces in the direct inputs of wastewaters, COD, PHC, NH_4-N to the NOWPAP sea areas

750-1500 tons for Cr and Pb, and about 40-50 tons for Hg and Cd (Fig 34). Unlike to organic matter the quota of Jiangsu province is not so minor, at least for Hg and, especially for Cd (Fig. 34).

It is necessary to take into account that wastewater outfalls directly discharged to the sea present only minor portion of the wastewaters generated and released in China as well as in any other NOWPAP countries.

For example, direct discharge of wastewaters to the sea from Liaoning, Shandong and Jiangsu provinces do not exceed 10% of the wastewaters generated at these provinces. For COD and NH_4-N

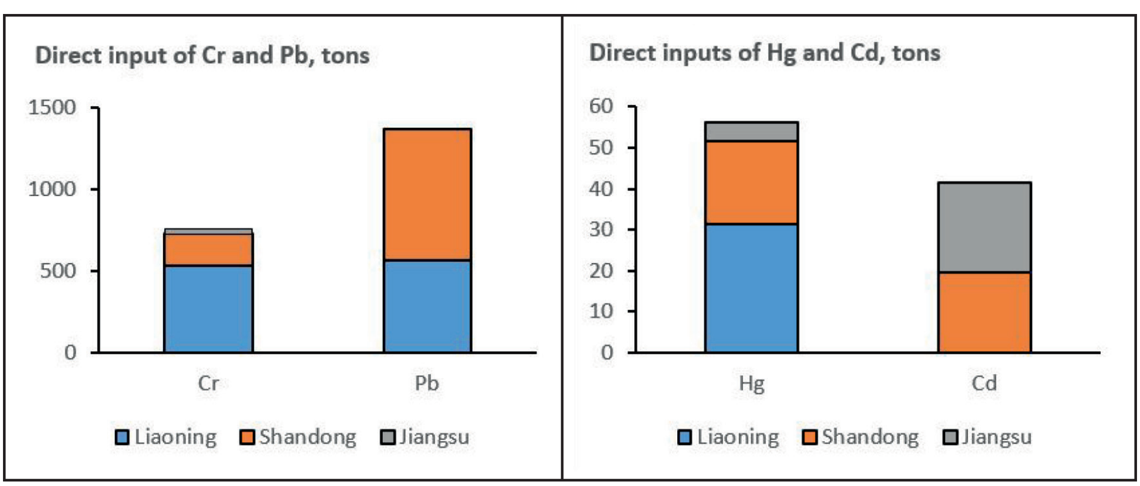


Figure 34. The quota of different northeastern Chinese provinces in the direct inputs of trace metals.

the quota provided by direct outfalls to the sea is even less (4-5%) (Fig. 33 and 35). There is notable increase trend in wastewaters generation during the last decade, especially in Jiangsu province. The inter annual change of COD and NH_4-N emissions is not so clear. At the same time for the discharge of petroleum hydrocarbons (PHC) distinctive decrease was observed for last five years (Fig. 35) reflecting efficient efforts on the treatment of wastewaters and preventing from oil spills. The same trend observed for the direct discharge of PHC (Fig. 32, 33) supports it.

In **Japan** as a whole, the data on the direct input of contaminants to coastal waters are not available. The data on the direct input of contaminant (BOD, COD, TN, TP) are reported only for the Toyama prefecture for 2012. (Data source: Toyama Prefecture Water Quality Program, published by Toyama Prefecture, 2015). Among the sources of contaminants in direct inputs, domestic wastewaters prevail for all substances except COD (Fig. 36). Non-point sources are dominated in the direct input of COD. This parameter reflects concentration of the unspecified organic substances, mobilized probably by surface runoff, and the major role of non-point sources (Fig. 36) supports it.

In **Korea** the data on direct inputs of contaminants to the sea areas is not available as well as in Japan. At the same time, input of contaminants from industrial wastewater and municipal sewage is controlled in Korea by the government in terms of concentration for selected water quality parameters (mg/L), such as COD, BOD, TN, TP, SS in discharged water (i.e., managing by Water Telemonitoring System). The efficiency of industrial wastewater and municipal sewage treatment showed that both were over 90% in total of contamination loads of industrial facilities and water treatment plants (Table 33 and 34).

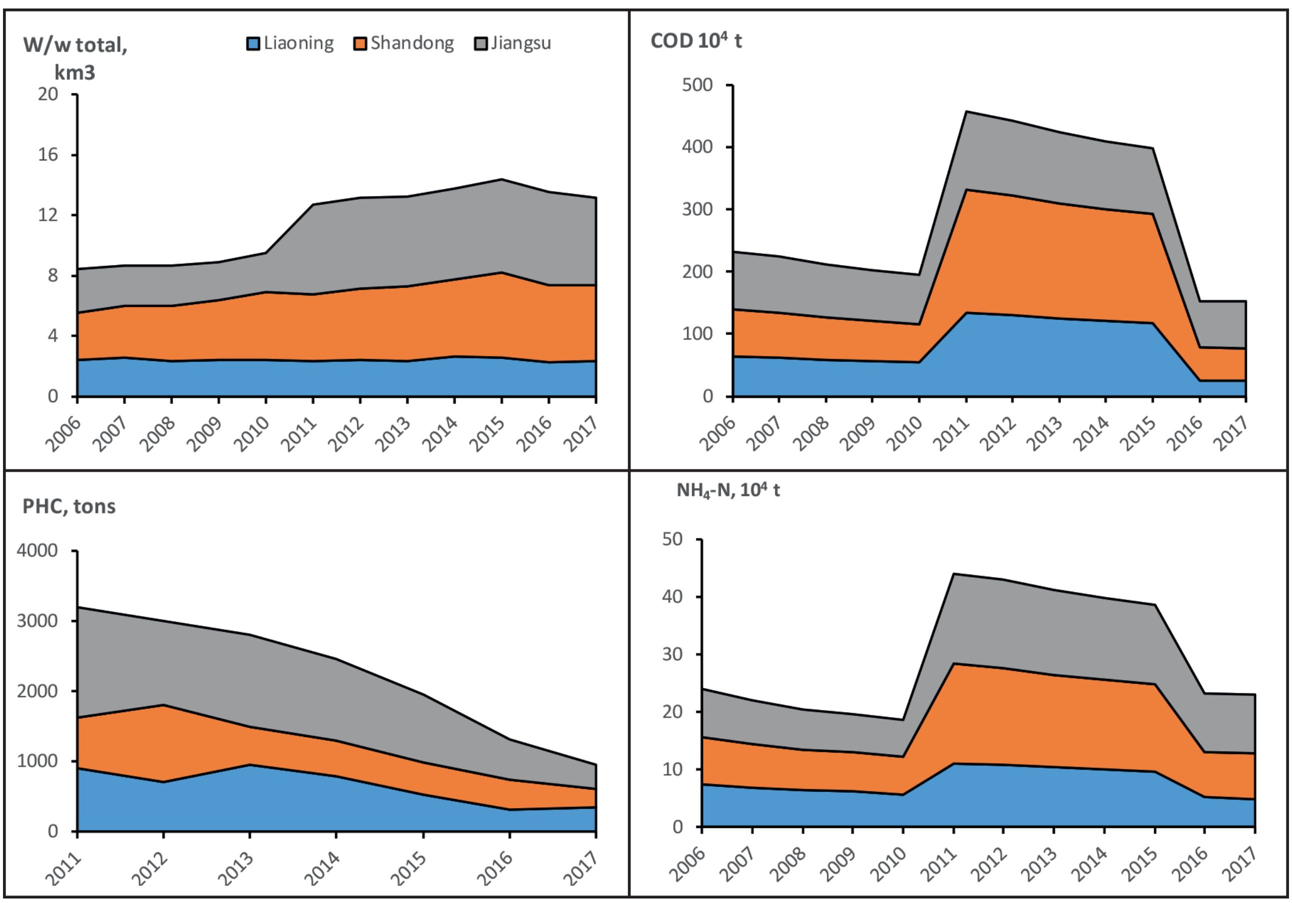


Figure 35. The quota of three northeastern Chinese provinces in the wastewaters, COD, PHC, NH_4-N generation (emission) and discharge (Source: China Statistical Yearbooks, 2011-2017)

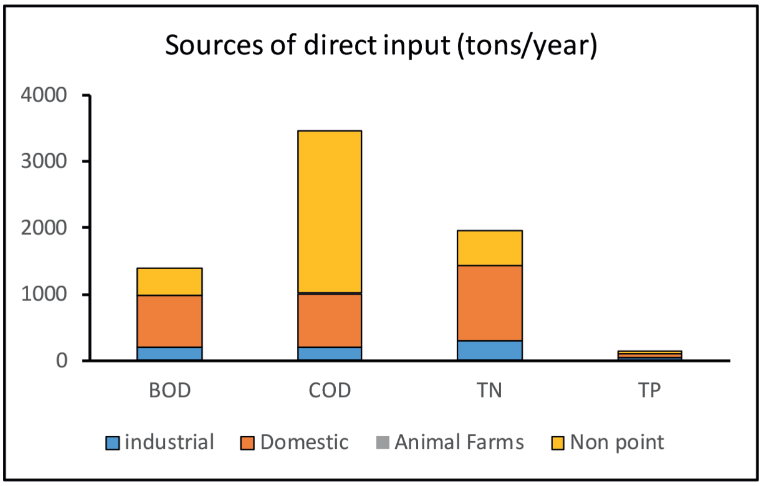


Figure 36. Sources of direct input of some contaminants in Toyama prefecture in 2012

Table 33. Contamination loads in input of industrial wastewater (before) and purified-water discharge (after) on the Korean four major river catchments in 2016. Values given in total for one year, and n corresponds to the number of facilities in each catchment.

Contamination load in wastewater (2016)		River catchment			
		Han River (*n* = 20)	Geum River (*n* = 61)	Yeongsan River (*n* = 22)	Nakdong River (*n* = 26)
COD (mg/L)	Before	4,972	15,888	6,489	7,286
	After	530	1,224	592	629
	Efficiency (%)	89.3	92.3	90.9	91.4
BOD (mg/L)	Before	4,882	19,609	7,299	9,274
	After	178	557	180	265
	Efficiency (%)	96.4	97.2	97.5	97.1
TN (mg/L)	Before	888	2,894	1,103	1,260
	After	363	1,062	360	379
	Efficiency (%)	59.2	63.3	67.4	69.9
TP (mg/L)	Before	191	505	201	242
	After	28	74	28	18
	Efficiency (%)	85.4	85.3	86.2	92.7
	After	173	716	155	259
	Efficiency (%)	95.4	95.5	97.2	95.5

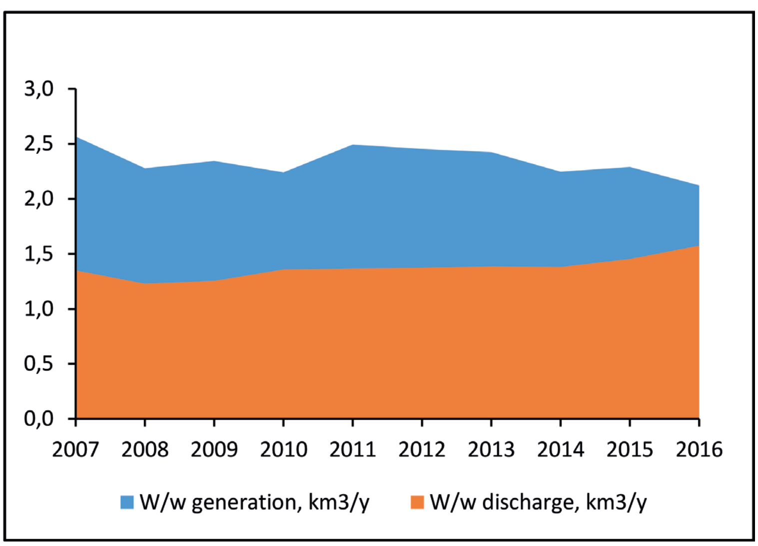


Figure 37. Inter-annual changes of wastewaters generation and discharge (km³/y) in Korea during the last decade (Source: Environmental Statistics Portal Online, 2019, Ministry of Environment (in Korean))

Table 34. Contamination loads in input of municipal sewage (before) and purified-water discharge (after) on the Korean four major river catchments in 2016. Values given in total for one year, and n corresponds to the number of monitoring stations in each catchment.

Contamination load in sewage (2016)		River catchment			
		Han River (*n* = 776)	Geum River (*n* = 385)	Yeongsan River (*n* = 218)	Nakdong River (*n* = 521)
COD (mg/L)	Before	73,669	32,027	17,106	39,126
	After	1,324	3,524	2,396	4,151
	Efficiency (%)	98.2	89.0	86.0	89.4
BOD (mg/L)	Before	29,021	51,164	23,507	59,125
	After	442	1,528	1,109	1,658
	Efficiency (%)	98.5	97.0	95.3	97.2
TN (mg/L)	Before	28,829	13,299	8,148	16,525
	After	1,668	4,714	2,777	5,866
	Efficiency (%)	94.2	64.6	65.9	64.5
TP (mg/L)	Before	3,224	1,463	1,012	1,856
	After	94	444	267	534
	Efficiency (%)	97.1	69.7	73.6	71.2

The amount of industrial wastewaters generated in Korea slightly decreased from 2.57 to 2.12 km^3/y during last decade at the wastewaters discharged increase from 1.35 to 1.57 km^3/y (Fig. 37). Spatial distribution of wastewaters generation and discharge within Korea is characterized by similar quota of five major big rivers, and small streams which provided major portions of wastewaters transport. Discharge of wastewaters from cities does not exceed 0.4 km^3/y (Fig. 38).

Information on the load of pollutants with wastewaters discharge in Korea is provided for the BOD mainly, though some data on the discharge of TN and TP are also available at the www.wamis.go.kr. Structure of BOD load with wastewaters after treatment is characterized by similar amount

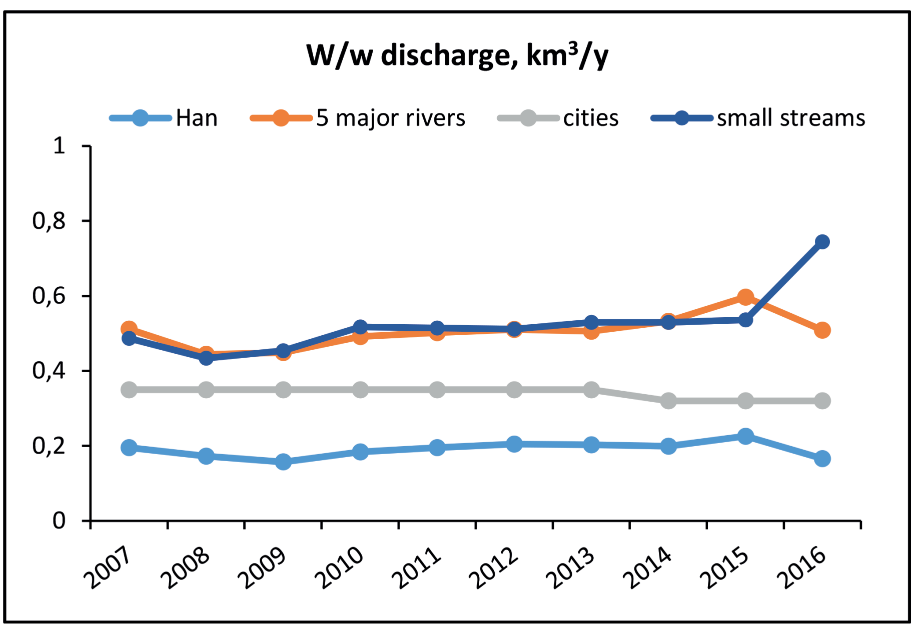


Figure 38. Wastewaters discharge provided by the sources situated at the watersheds of major Korean rivers (and separately by Han R.), small streams/rivers directly inputted to the sea, and cities are not drained by mentioned rivers.

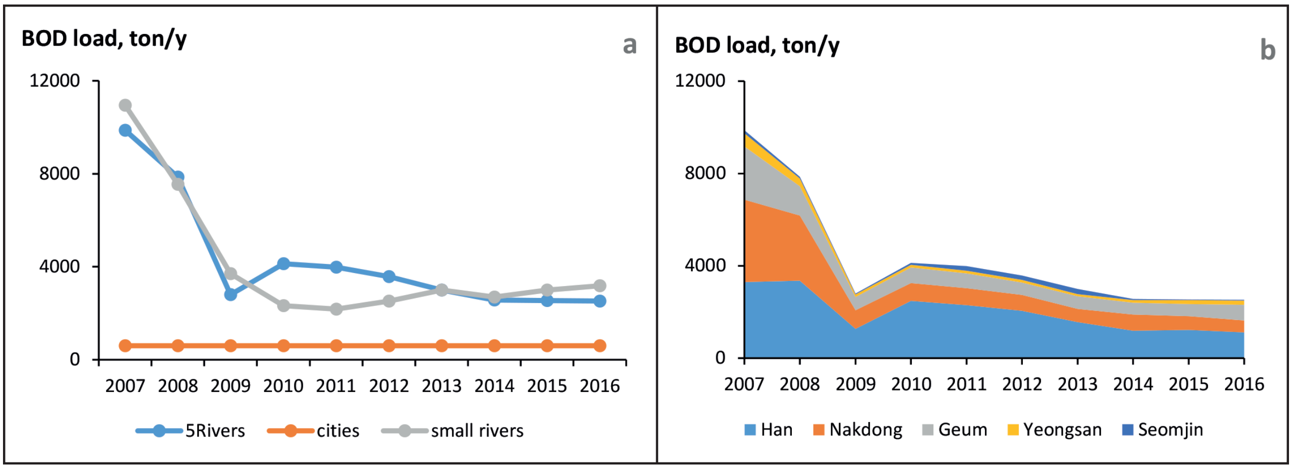


Figure 39. Dynamic of BOD load from different sources (a) and at the watersheds of major Korean rivers during last decade

discharged to five major rivers and all other streams of country (Fig. 39). During the last decade BOD load to the rivers significantly declined in 2007-2009 and continued to decrease more slowly after that. Load of BOD through the city wastewaters was expressively lower and rather constant during the last decade (Fig. 39a). More detailed analysis of BOD load to five major Korean rivers confirms substantial decrease of BOD discharge during the last decade. At the watershed of the Nakdong and Geum rivers the drop of BOD load was observed in 2007-2009, though improvement of water quality of the Han R. was more graduate during the last decade (Fig. 39b). In any case notable progress in terms of decrease pollution by oxidizing organic matter takes place in the surface waters of Korea. The improvement of wastewaters treatment technology is the most probable reason.

The most reliable data on the direct inputs of contaminants in **Russia** can be obtained from the analysis of data on the water consumption and wastewaters generation and release. The purification degree of wastewaters at least qualitative is also monitored and reported in Russia. Additional information on the amount of wastewaters and some contaminants like BOD, NH_4-N, TP or DIP is available for the major sources of wastewaters. In accordance with distribution of population and economic activity Primorye region and Sakhalin are the main sources of the generation and input of contaminants in the Russia within the NOWPAP area. The quota of the districts within Khabarovskii Krai does not exceed 3-5% in terms of population and wastewaters generation and release.

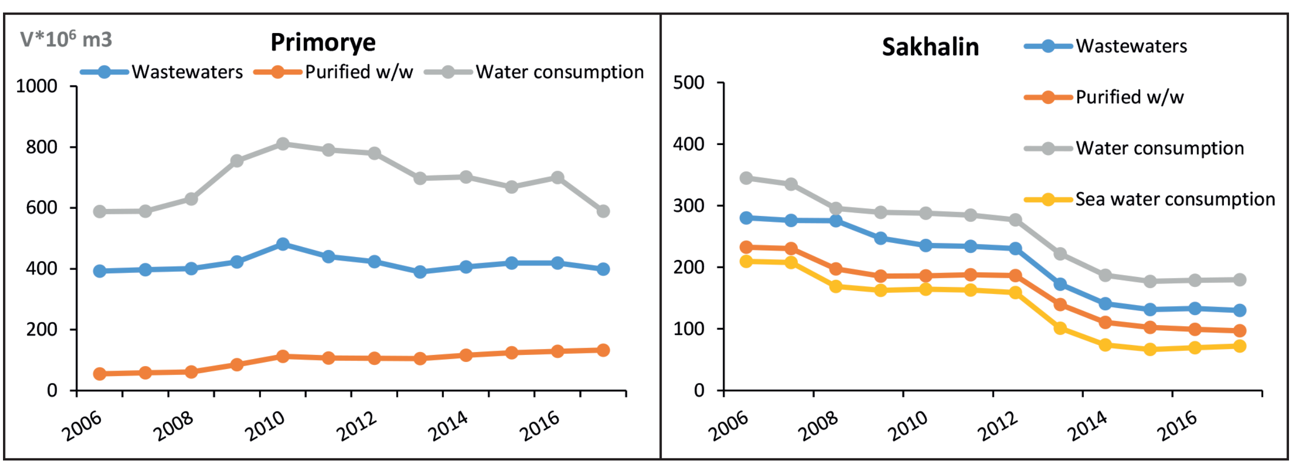


Figure 40. Dynamic of water consumption and wastewaters release during last decade in Primorye and Sakhalin areas (http://mpr.sakhalin.gov.ru., Primstat)

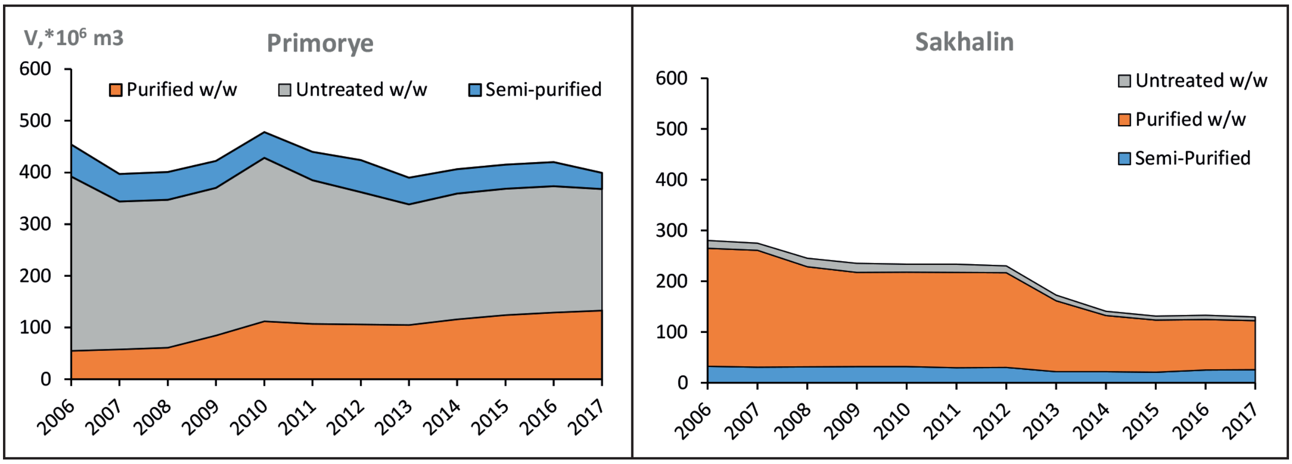


Figure 41. Dynamics of wastewaters with different purification degree during the last decade in Primorskii Krai and Sakhalinskaya oblast (http://mpr.sakhalin.gov.ru., Primstat)

Water consumption in Primorskii Krai during the last decade reached the annual maximum 810*10^6 m^3 in 2010 and after that showed slight decrease trend to 589-700*10^6 m^3 (0.6-0.7 km^3) in 2016-2017 (Fig. 40). Water consumption in Sakhalin area demonstrated more clear decrease trend from 345*10^6 m^3 in 2006 to 180*10^6 m^3 in 2017. This trend is explained by the reduction of consumption of sea water, which is used as a cooling agent at the industrial enterprises, power plants, first of all. The quota of sea water in the water consumption in Sakhalin reached up 61% in 2006 and is about 40% even now. The significant quota of sea water is a reason of elevated consumption of water per capita in Sakhalin compare with Primorye.

The amount of generated and released wastewaters in Primorskii Krai slightly declines from 337-340*10^6 to 290-299*10^6 m^3 during last decade, and it is 41-57% of the water consumption. The quota of properly purified wastewaters in Primorye was only 16% of all amount of wastewaters in 2006, but it significantly increased up to 44% in 2017 (Fig. 40), reflecting serious and successful efforts of local governments on the proper water management. In Sakhalin area the amount of generated and released wastewaters decreased in accordance with the decline of water consumption during the last decade (Fig. 40), but the ratio of wastewaters to water consumption was more stable, and just slightly decline from 81 to 72-74%. Higher ratio of wastewaters to water consumption in Sakhalin

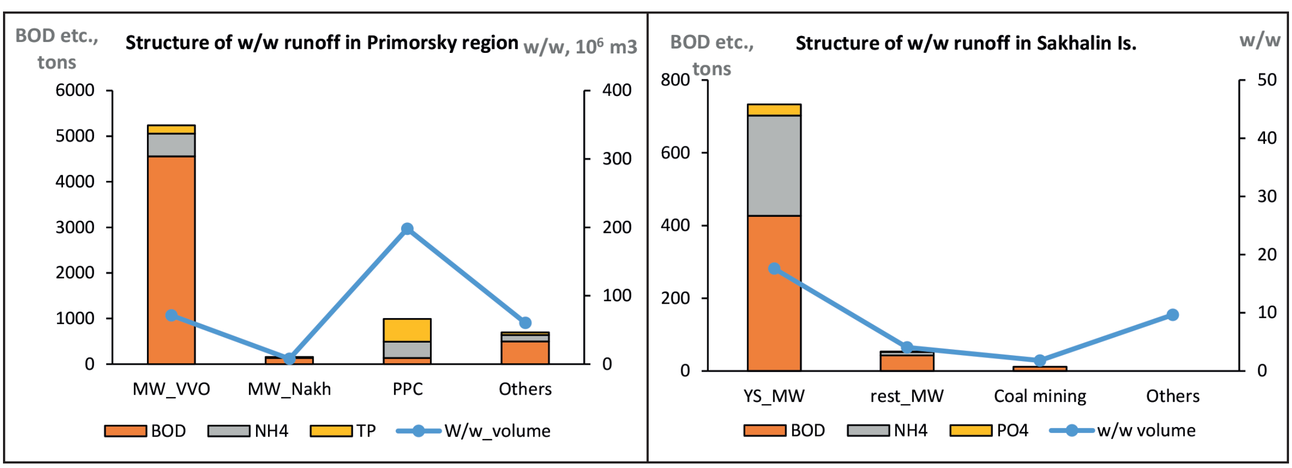


Figure 42. Major sources and structure of wastewaters inputs in Primorye and Sakhalin areas (Natural resources and Environmental protection of Primorakii Krai, 2017, Reports on ecological status and environmental protection in Sakhalinskaya Oblast, 2006-2016)

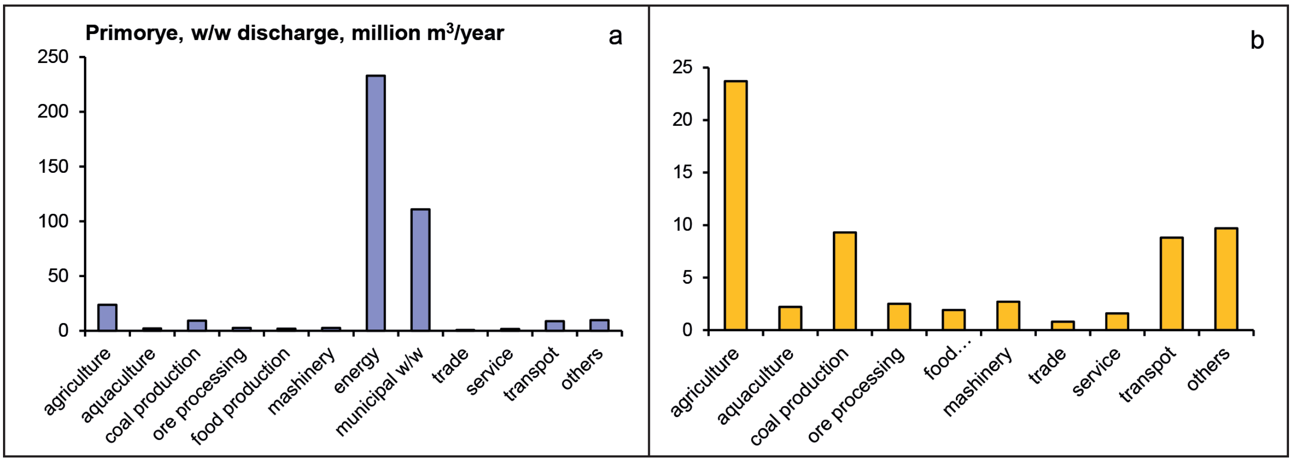


Figure 43. Human activities responsible for the wastewaters discharge in Primorskii Krai in 2007 (POMRAC Technical report #7, 2009).

compare with Primorye could show on the less common secondary (recycled) usage of water resources in Sakhalin. However, from other side the quota of properly purified wastewaters in Sakhalin varies from 83 to 75% (Fig. 40) and water treatment systems at Sakhalin Is. are more effective compare with Primorye. It is supported by the dynamic of amount of properly purified, semipurified, and untreated wastewaters during the last decade for two major administrative Russian areas within the NOWPAP region (Fig. 41).

The input of different contaminants with wastewaters in Primorye and Sakhalin (Fig. 42) shows the dominance of municipal wastewaters of big cities Vladivostok (MW_VVO) and Yuzhno-Sakhalinsk (YS_MW) as a source of organic matter in direct inputs. BOD, NH_4-N and TP are the major contaminants monitored and reported. Power plants cooling (PPC) is also an important source of wastewaters in Primorye, at least in terms of a volume, that is thrice more than the volume of municipal wastewaters. Therefore even at rather low concentration of contaminants in the wastewaters from cooling systems, the direct inputs of BOD, N and TP due to these wastewaters is notable (Fig. 42).

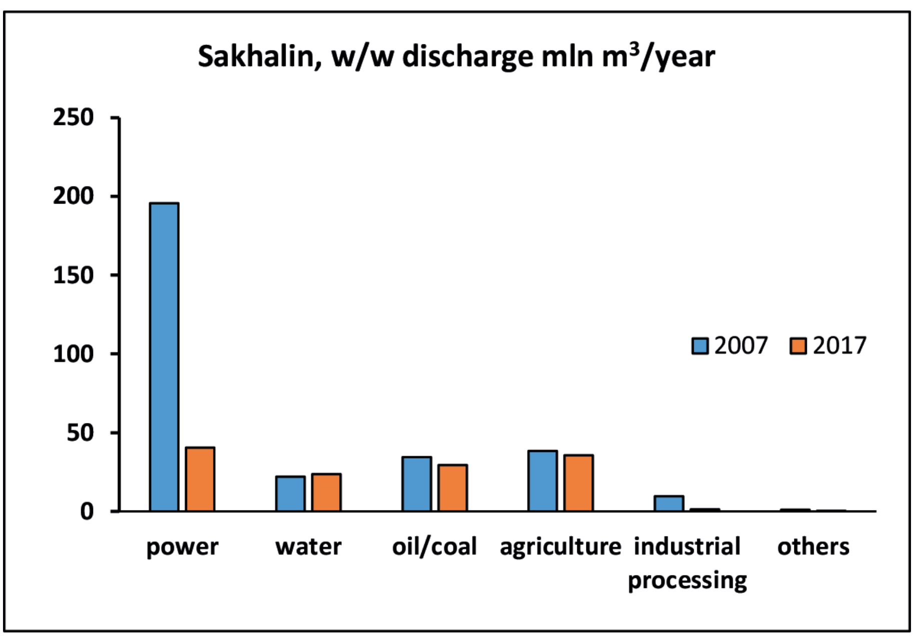


Figure 44. The quota of different kind of human activities in the generation of wastewaters at Sakhalin Is. during last decade.

Coal mining of Sakhalin Is. is accompanied by elevated concentration of contaminants in the drainage waters, but their volume is not high enough to effect on the runoff of contaminants in a regional scale (Fig. 42).

In 2007 power and heat generation was a major in terms of wastewater discharge (Fig. 43a) (POMRAC, 2009). Municipal water usage, treatment and discharge were the second ones. Other activities generated and released less than 15% of total amount of wastewater. It does not mean the harmless of wastewaters generated and discharged at the coal production or ore mining/dressing. The ecological threats and damages from these kinds of activity can be very severe, but rather local. Agriculture, coal production and transport become the most significant source of pollution, at the excluding of power generation and municipal water usage (Fig. 43b). The structure of wastewaters in Rrimorye within the NOWPAP region did not change during last decade.

The power (electricity) production is a major source of wastewaters discharge at the Sakhalin Is. (Fig. 44), but significant decrease of wastewaters connected with power production was observed during last decade due to improvement of technology.

9. Quota of different sources in the input of contaminants to the NOWPAP sea areas

In **China** due to some features at the reporting of monitoring results on river water quality, the latest assessment of fluxes of water and chemical substances can be done for 2010 only. Moreover, data availability is restricted by several rivers, and extrapolation of these data on all watersheds of northeastern Chinese provinces would be too rough. Liaoning province is the only exception where two major rivers the Yaluhe and the Daliaohe can be accounted and compared with data on wastewaters generation and discharge at the watershed and with direct inputs to the sea (Fig. 45).

Obviously, that volume of wastewaters discharge consists of the very minor part (4%) of river runoff, but the amount of organic substances (COD) and nutrients released and discharged with wastewaters prevails over the same transported to the sea by rivers. The quota of wastewaters is higher for the substances like COD (proxy of organic matter) and ammoniac nitrogen, and decreases for TN presented by oxidized nitrates mainly. The quota of wastewaters declines further for petroleum hydrocarbons (PHC), reflecting the upsurge of wastewaters purification from PHC. The portion of contaminants delivered by direct inputs does not exceed 3-8% for all substances (Fig. 45).

For the trace metals monitored as pollutants (Pb, Hg) the quota of direct inputs assessed on the example of Liaoning province does not exceed 0.1%, (Fig. 46) that is strong majority of metals is delivered to the coastal areas with river runoff. In reality, the role of rivers as a transport way for the contaminants in China is higher, because Fig. 46 is based on the assessments of fluxes of three rivers (the Dalinghe, the Daliaohe and the Yluhe) only.

The dynamic of direct inputs of contaminants in three northeastern Chinese provinces (Liaoning, Shandong and Jiangsu) during the last decade (Fig. 33, 35) allows us to suppose continuation of

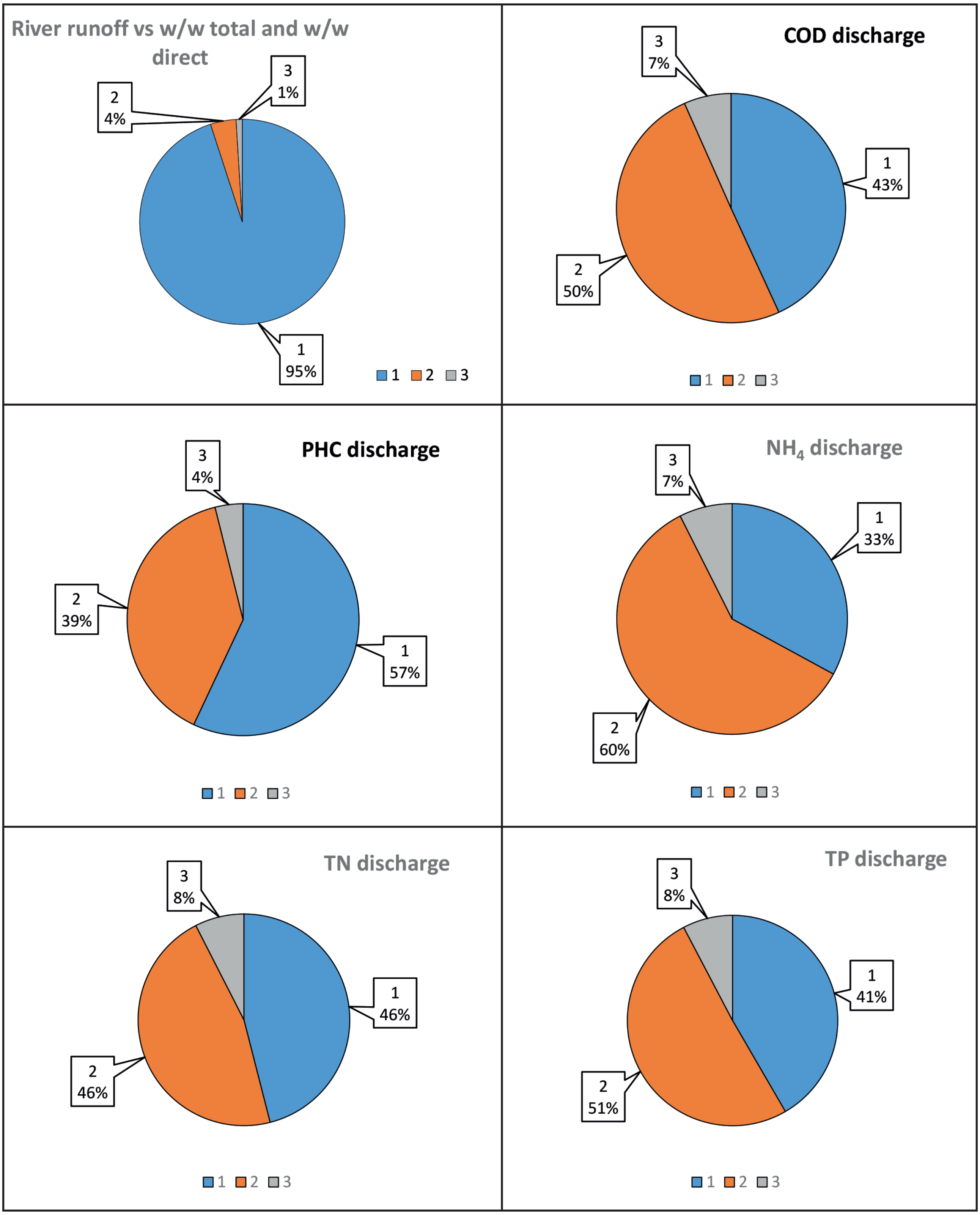


Figure 45. The quota of river runoff (1), wastewaters discharge (2), and direct inputs (3) from Liaoning province in terms of water volume, and contaminants emission: organic matter (COD), petroleum hydrocarbons (PHC), ammonia nitrogen (NH_4), total nitrogen (TN) and total phosphorus (TP). (Source: China Statistical Yearbooks)

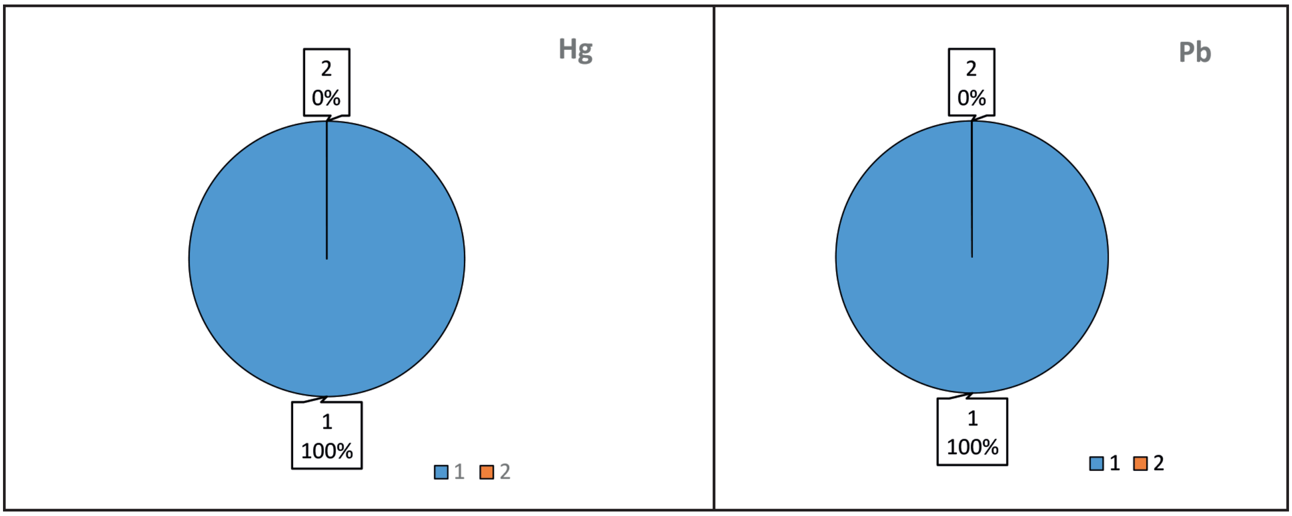


Figure 46. The quota of river runoff (1), and direct inputs (2) from Liaoning province in the input of Hg and Pb to the sea (Source: China Statistical Yearbooks)

the prevalence of river runoff as a major source of contaminants to the coastal areas compare with direct inputs. The comparison of river runoff of contaminants with the amount of wastewaters generated and released at the watersheds could be supposed as a measure of anthropogenic impact on the water ecosystems.

The data on the direct input of contaminants to the coastal sea are not available for the area facing the NOWPAP region in **Japan** as a whole**.** The data on the direct input of contaminant (BOD, COD, TN, TP) is available only for the Toyama prefecture for 2012. From these data it follows, that percentage of the direct input in the sum of river and direct input is 9.7% (BOD), 10.3% (COD), 13.4% (TN) and 20.7% (TP) (Fig. 47. Therefore, contribution of the direct input to the total discharge varies according to contaminants but in general contribution of direct input to the total input is approximately 10 to 20 %. The volume of wastewaters discharged in Japan directly is not registered. The data on the volume of wastewaters generated in Japan as a whole can be assessed by the data on the water use for different use (Fig. 10). The total volume of water use nationwide

The data on the volume of water consumption and wastewaters generation in Toyama prefecture is not available, but we can presume that water consumption/wastewaters generation is proportional in general to the population in the developed society, that is the case for Japan. Based on this assumption, and taking into account the population (1.07 mln persons) and averaged river runoff for Toyama prefecture, one can calculate the relationship between river runoff and water consumption (Fig. 48). Obviously, that all water consumption in Toyama prefecture does not exceed 6% of river runoff, and 2/3 of this volume is presented by waters used for agriculture.

Despite the strong prevalence of natural sources in the water balance in terms of water volume, the anthropogenic influence on the balance of contaminants in terms of their fluxes is not so minor (Fig. 49).

The assessment has been made for the quota of industrial, domestic wastewaters, and sewages from animal farms to the river runoff of major contaminants (BOD, COD, TN and TP) compare with non-point sources of the same substances within Toyama prefecture in 2012 (Toyama Prefecture Water Quality Program, 2015). For BOD, TN and TP the quota of non-point sources which can be assumed as natural mainly vary around 60% of river runoff. The rest are equally provided by industrial and domestic sources for BOD and TP, and by the industrial ones mainly for TN. The quota of non-

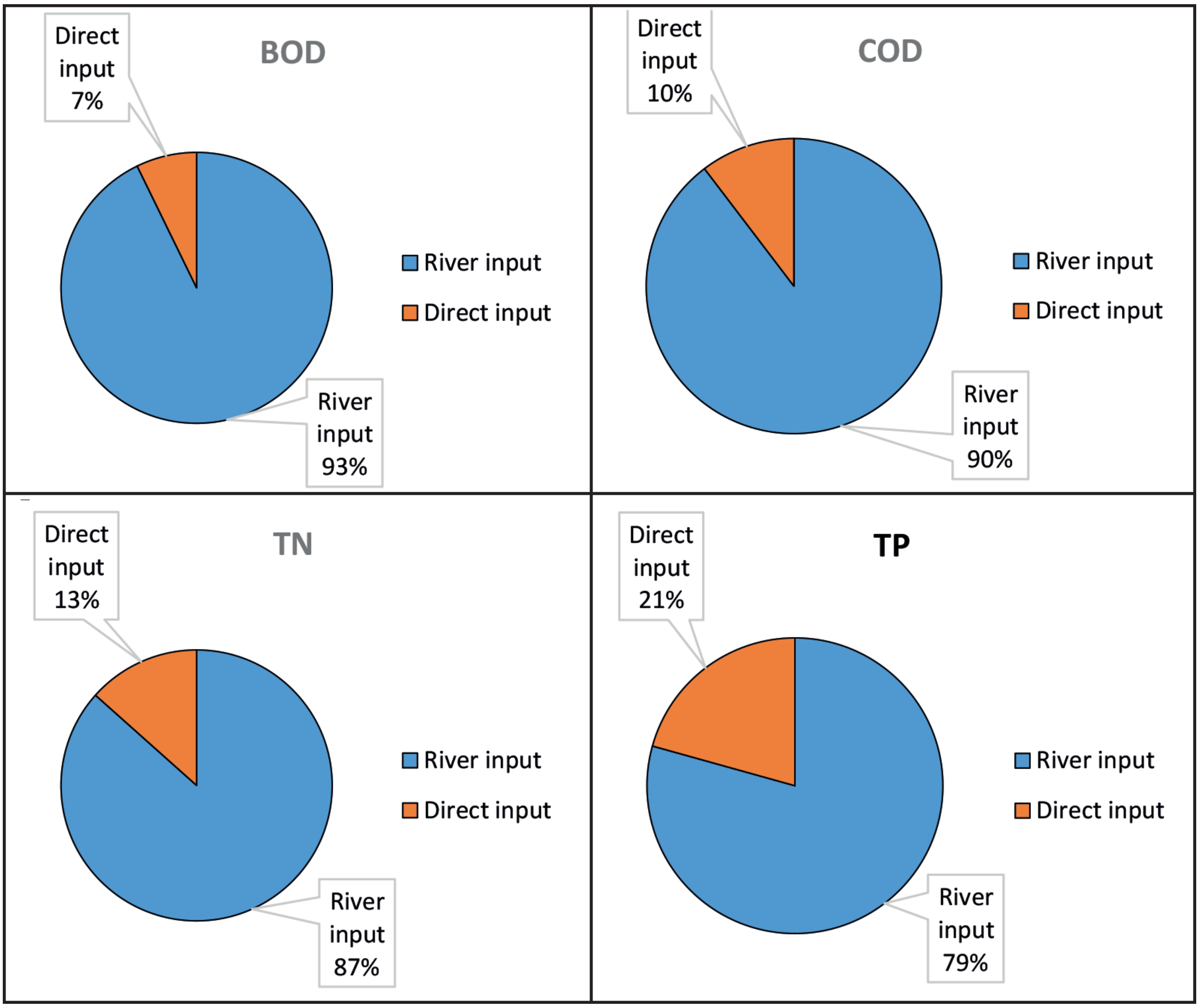


Figure 47. The quota of river and direct inputs of contaminants (BOD, COD, TN and TP) within Toyama prefecture in 2012 (Data source: Toyama Prefecture Water Quality Program, published by Toyama Prefecture, 2015)

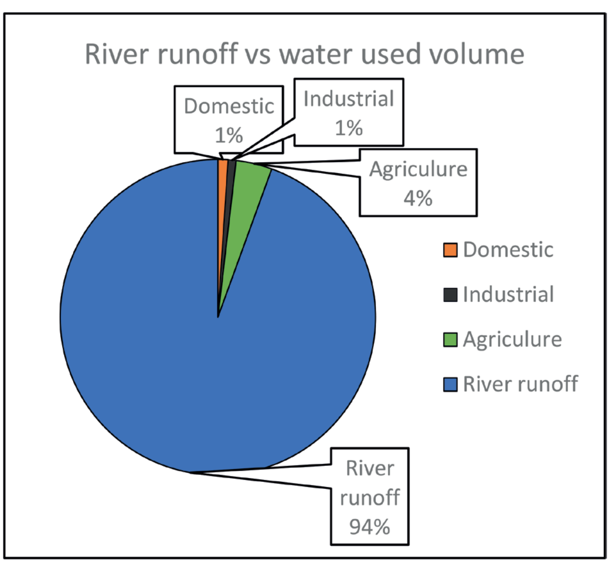


Figure 48. The relationship between the volume of river runoff and water use for the different purpose in Toyama prefecture (based on the available data for 2012)

point sources in the COD river runoff is enlarged up to 82%, reflecting relatively less dependence of this parameters on the anthropogenic activity. Sewages from animal farms have practically negligible influence on the river runoff for all contaminants at least for Toyama prefecture. It reveals the high efficacy of the animal farms sewage treatment in this region. However, local influence of the animal sewages on the surface waters cannot be excluded.

In **Korea** the amount of industrial wastewaters discharged and domestic sewages are registered separately. The volume of industrial wastewaters within the watersheds of five major Korean rivers does not exceed 1% of their annual runoff, and even the wastewaters discharged

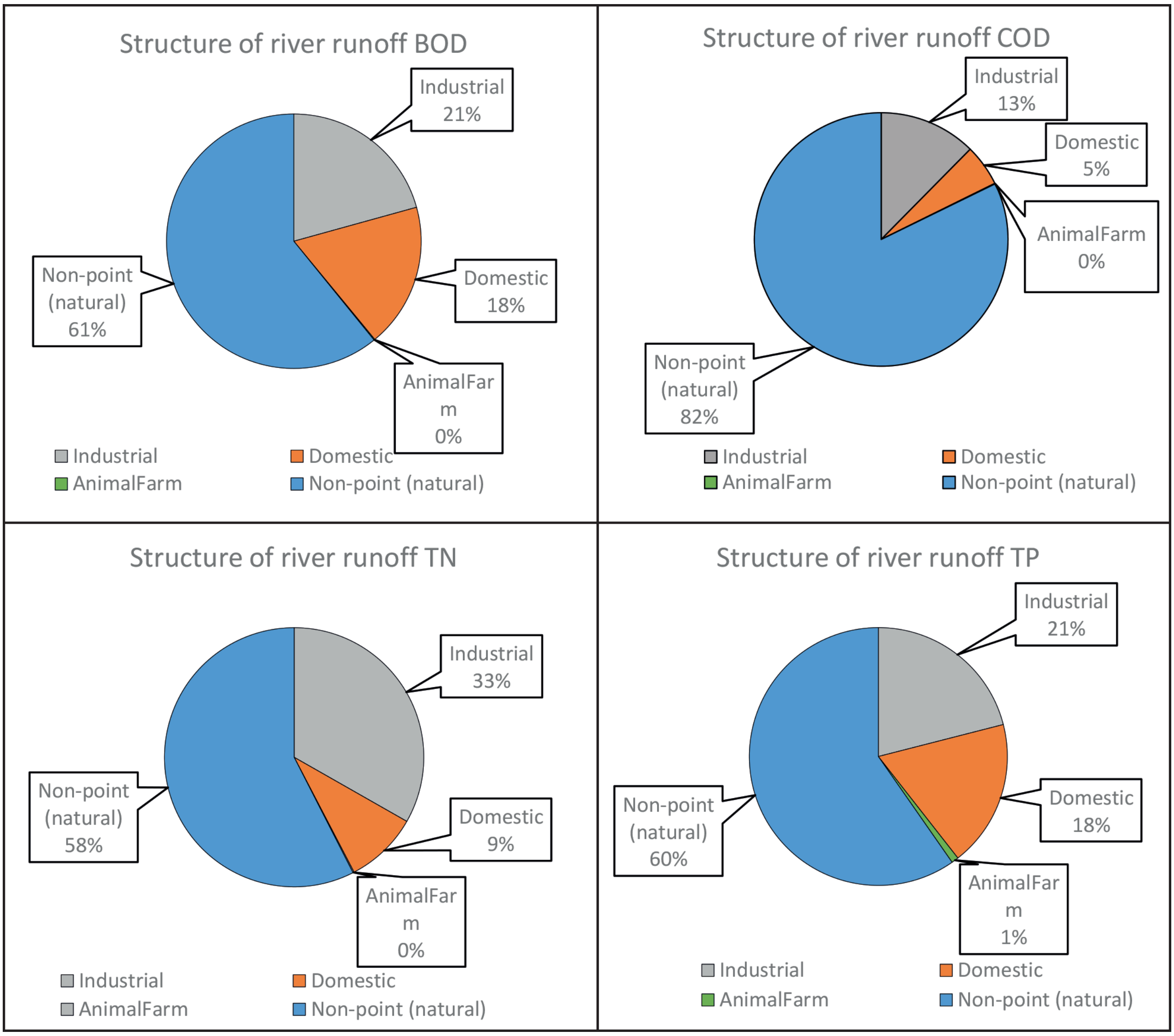


Figure 49. The quota of different sources providing the river runoff of contaminants within Toyama prefecture in 2012 ((Data source: Toyama Prefecture Water Quality Program, published by Toyama Prefecture, 2015)

in Korea as a whole do not exceed 3% of river runoff. The amount of domestic sewage in Korea varied in range 5.3-6.8 km^3/y during last decade (www. kosis.go.kr) that is about 10% of the river runoff (Fig. 50).

The quota of BOD load provided by industrial wastewaters within watersheds of five major Korean rivers compare with BOD fluxes provided by river runoff did not exceed 2% in 2016 (Fig. 51 upper left), that is only twice higher than the quota of wastewaters in terms of the volume (Fig. 50). Even BOD load provided by wastewaters at entire Korea did not exceed 5% of BOD with river runoff (Fig, 7.27, bottom left). At the same time in 2007 the similar parameters were 7% and 14%, respectively (Fig. 7.27 upper right, bottom right). It means significant improvement in the treatment of industrial wastewaters in terms of BOD amount.

In **Russia** the volume of wastewaters is available from the official statistic data along with data on the contaminants released by the major source of pollution (Natural Resources and Protection of Environment…, 2007-2017). It allows to evaluate the input of some contaminants with waste waters from Primorskii Krai and from the south part of Sakhalin Is. Further comparison of these data with

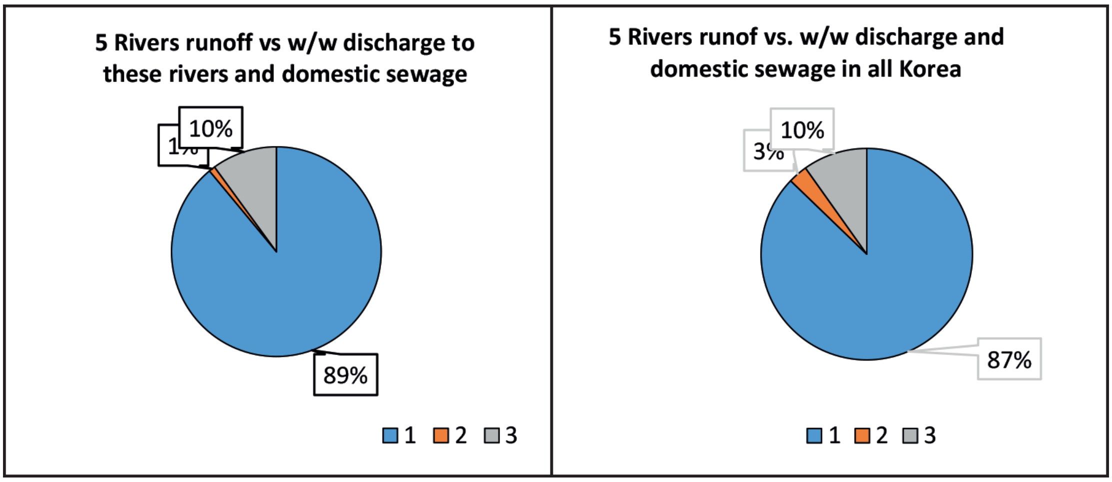


Figure 50. The quota for 2016 of river runoff of 5 major Korean rivers (1), industrial wastewaters (2) and domestic sewages (3) discharged within watersheds of major rivers (left) and in Korea as a whole (right) in terms of water amount. (Data source: (1) www.wamis.go.kr; (2) Environmental Statistic Portal 2019 (in Korean); (3) www.kosis.go.kr)

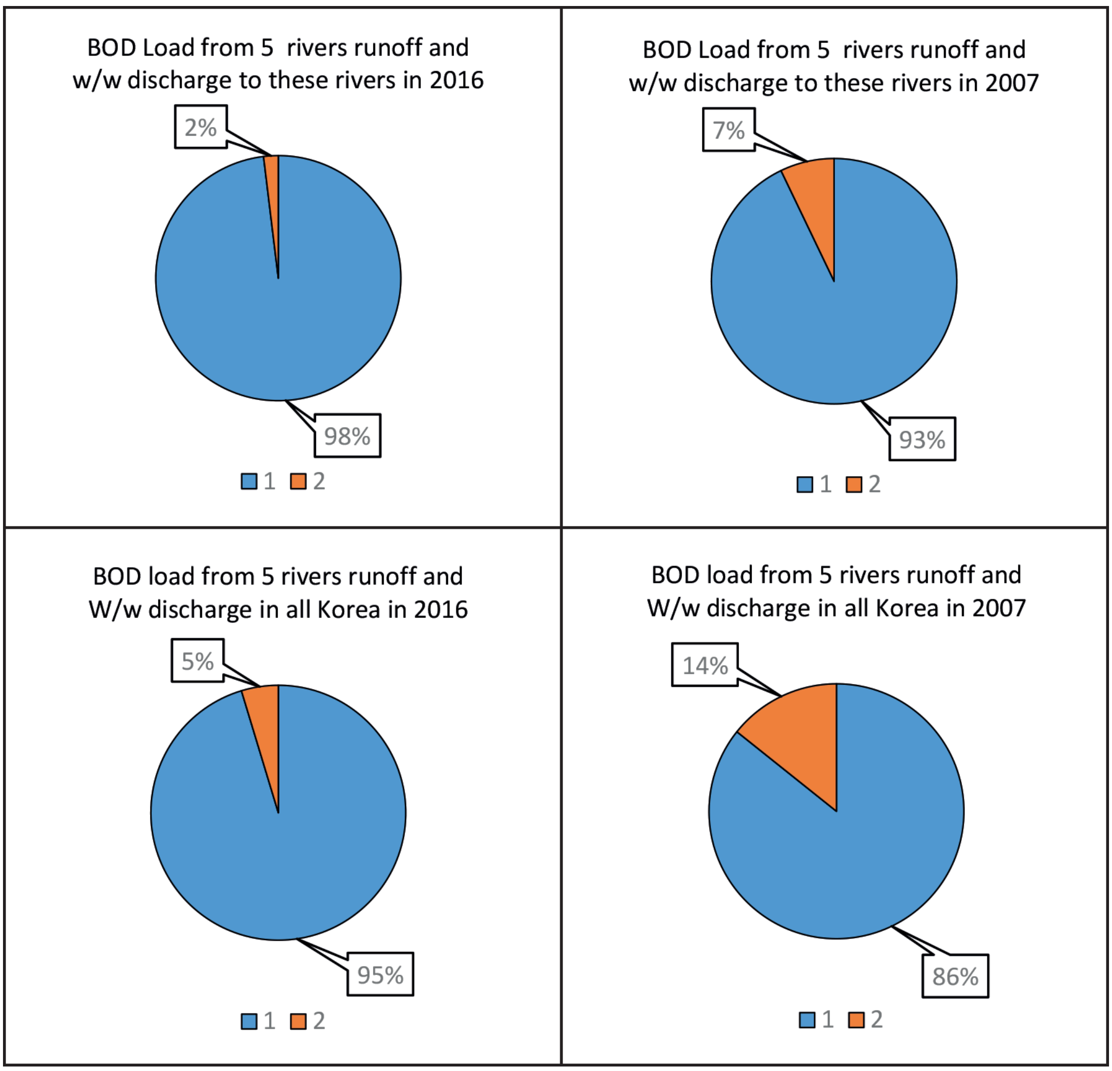


Figure 51. The quota of BOD load with industrial wastewaters at the watersheds of 5 major rivers compare with BOD river runoff in 2016 (upper left) and 2007 (upper right), and the same for the BOD load with wastewaters discharged at all Korea in 2016 (bottom left) and in 2007 (bottom right). (Data source: Environmental Statistics Portal Online, 2019, Ministry of Environment (in Korean), www.wamis.go.kr and Table 30)

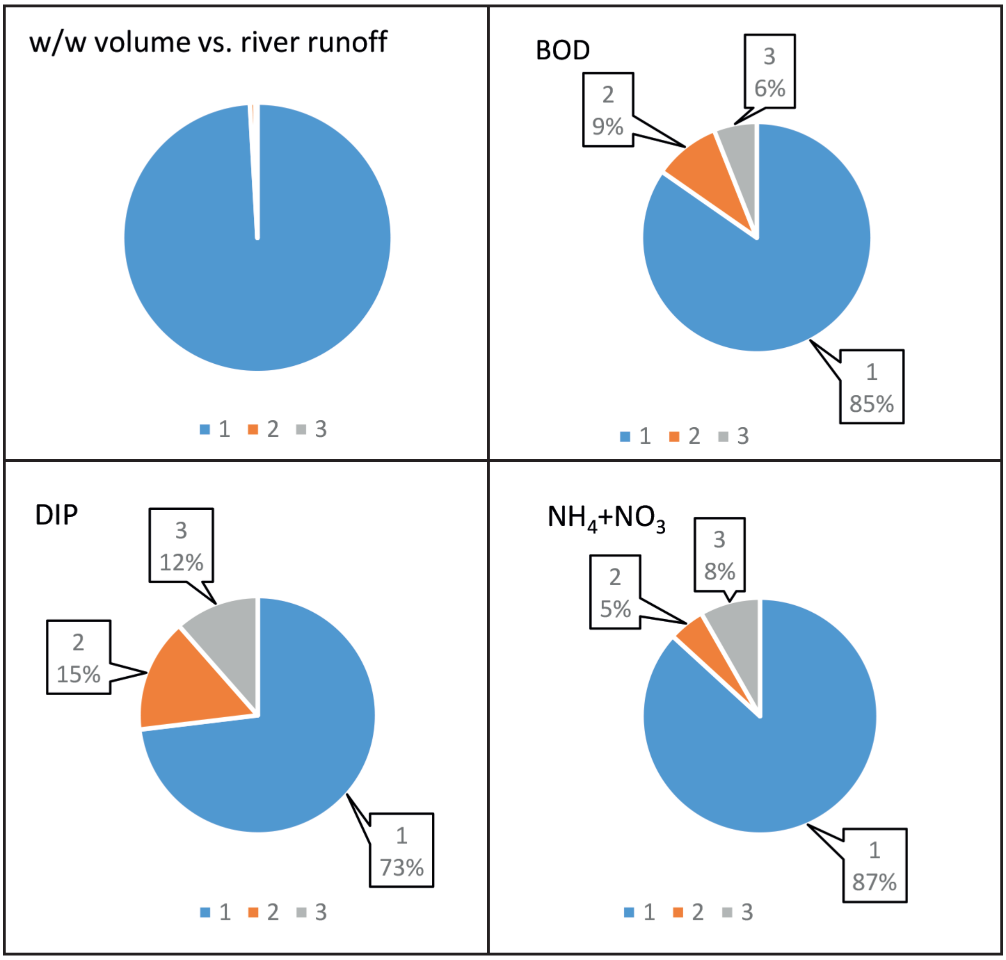


Figure 52. The quota of the river runoff (1), wastewaters from Primorye (2) and wastewaters from the south part of Sakhalin Is. (2) in the input to the NOWPAP sea area in terms of water volume, and contaminants: organic matter (BOD), phosphates (DIP), and dissolved nitrogen (NH_4+NO_3)

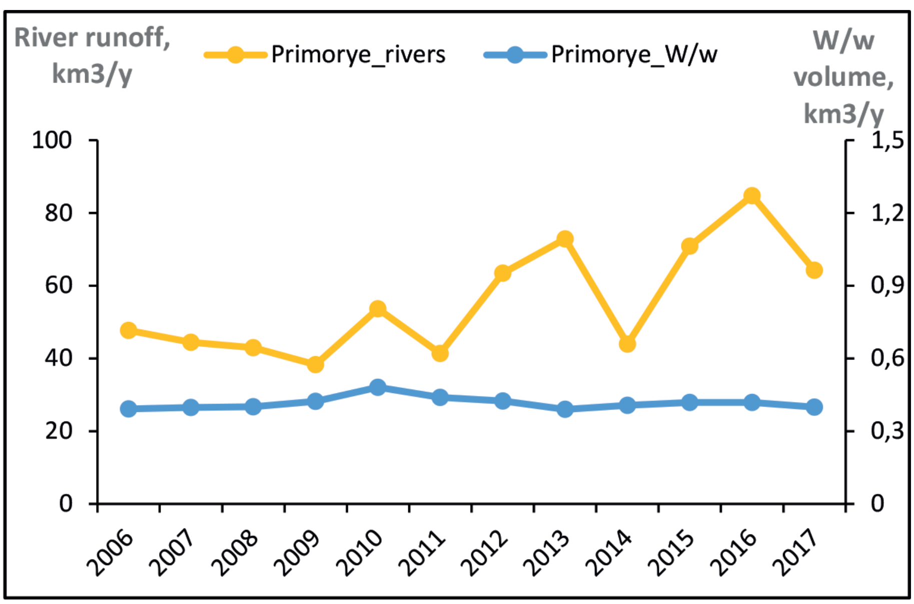


Figure 53. Inter-annual changes of river runoff and wastewaters volumes in Primorskii Krai region during last decade (Source: Primstat, 2006-2017, www.gmvo.skniivh.ru)

the assessment of river fluxes of contaminants (Table 31) normalized to the all river runoff from the Russian territory within the NOWPAP region gives the assessment of the ratio between the river run-off and wastewaters as the sources of contaminants to the sea (Fig. 52).

The inter-annual variability of the river water runoff of the moderate climatic zone is notable. For example, the last 4-5 years annual river runoff from Primorye is characterized by the 1.8 times increase compare with multiyear average (Fig. 53). At the significant predominance of the water river runoff over the wastewaters volume, the quota of contaminants provided by wastewaters continues to be the same, or decreases during the last years (Fig. 53), and variations of this quota is determined by variability of the river runoff first. At the same time, it is clear, that extremely high spatial heterogeneity in distribution of wastewaters outputs in combination with seasonal and inter-annual variability of the river runoff inevitably makes such assessment rather rough. Minor input of contaminants with direct wastewater discharge at the regional scale does not exclude prevalence of such sources at the local scale. The Golden Horn Bay, eastern part of Amursky Bay, and some other semi enclosed bights of Peter the Great Bay in Russia are the most obvious examples of such "hot spots" in terms of impact of direct inputs and wastewaters on the coastal waters.

10. Conclusions

River runoff and direct inputs along with wastewaters release are the main land-based sources of contaminants for the coastal sea areas. Evaluation of these fluxes is necessary for any environmental assessment. The current data on the river water quality and riverine fluxes of some contaminants within the NOWPAP region along with the data on direct inputs of contaminants and wastewaters generation and release are the first major goal of this regional overview. The second goal is to present inter-annual trends in river and direct inputs of contaminants during last decade.

Anthropogenic activity is the main driver of many water quality problems in the NOWPAP region. Therefore, short description of socio-economic features of the NOWPAP countries is provided at the beginning of this overview. All NOWPAP countries showed sustainable growth of GDP during the last decade, though population within each country was quite stable and even slightly declined in Russia and Japan. Very significant spatial heterogeneity in the distribution of population and degree of land use is a special feature of Russian territories within NOWPAP region (Primorye and Sakhalin). The notable (3-4 times) growth of fertilizers usage is another feature of anthropogenic activity in Primorskii Krai during the last decade. Much denser and evenly distributed population and economic activity is typical for China, Japan, and especially, Korea.

Water consumption, wastewaters generation and the degree of treatment of water used could be recommended as useful indicators of the anthropogenic impact on the river water systems. In combination with the existing data (if any) on the contaminants concentration and inputs with wastewaters of different types it allows to get reliable background for the assessment of anthropogenic impact on the river and coastal water ecosystems, and to compare river and direct inputs of contaminants. Dynamics of wastewaters generation during the last decade depends on the economic features of provinces/subregions: for example, in Russia in Primorskii Krai wastewaters volume continued to be rather constant, but in Sakhalin – decreased due to reduction of waters used for cooling at the electric power production. In Liaoning province of China wastewaters generation was stable, but in Shandong and especially Jiangsu provinces the volume of wastewaters showed a notable increase. Despite the different trends in the volume of wastewaters generated, the significant improvement of wastewater treatment was observed in all NOWPAP countries during the last decade. It is especially true for petroleum hydrocarbons contamination that is expressed in the decrease of PHC concentration in the wastewaters in northeastern Chinese provinces. For other organic pollutants (COD, BOD, nutrients) improvement in wastewaters treatment is notable, but not so significant during the last decade, at least within northeastern Chinese provinces.

In Japan the rate of the domestic sewage treatment was rather high even 30 years ago, and continued to be at the high level during the last decade. The industrial wastewaters in Japan are strictly regulated and accounted in terms of concentration and fluxes of contaminants, though the quantitative data on this topic are not freely available. Rather stable concentration of the majority of contaminants below the ecological quality standards confirms the success of the water and wastewaters management in Japan during last decade.

Volume of wastewaters generated in Korea has decreased in 18% during the last decade, but wastewaters discharge demonstrated 16% increase during the same period. Efficacy of industrial wastewater and municipal sewage treatment at the industrial facilities and water treatment plants in Korea reached up 90% in average of contamination loads. At the same time efficiency of the purification from TN does not exceed 70%, and even treated wastewaters continue to be notable excessive source of nutrients to the coastal ecosystems.

The trends in river water runoff is determined by the natural factors mainly, though anthropogenic control such as dam construction, or influence on the climatic characteristic cannot be excluded. The anthropogenic impact on the river water quality is much more pronounced, and has to be characterized and assessed. The data from the NOWPAP states monitoring services was the main source of such an assessment in this overview. Therefore, significant attention was given to the features of national monitoring systems in the NOWPAP countries. It was shown that existing inconsistency in the EQS, methods of sampling and analysis is not critical, and could be overcome if the data are presented as concentration of substances. At the same time comparison of the data becomes very hampered after presenting the information on water quality in the form of "grades", "classes", "indices". Latter ones have higher potential to be used in different countries if unequivocal valuation procedure is open to analysis. Reliable scientific papers were another source of information on river water quality in terms of concentration of some trace elements and organic micro pollutants, and in terms of elaboration of unified indices.

The possibility to assess the inter annual trend in river water quality is determined by the national features of the reporting of the river water quality monitoring results in the NOWPAP countries. In China the official averaged data on water quality is available by 2010 only for the five typical rivers with different level of anthropogenic impact and different size from small polluted Dalinghe to huge and rather clean Changjiang (the Yangtze R.). Polluted rivers showed clear improvement in terms of PHC concentrations. Decrease trend of COD and BOD parameters was also observed, not only for heavy polluted small Dalinghe, but also for the much bigger Dalinhe and Tumen rivers with water runoff 6.8-14.8 km^3/y. In Russia rather clean rivers of the Ussury basin draining less populated watersheds are comparable on BOD and NH_4-N concentration with similar Chinese rivers (Yalu R.). Inter annual changes of the chemical composition of Russian rivers within the NOWPAP region is characterized by the pronounced increase of nitrates during last two decades. This growth was maximal in the rivers under significant anthropogenic impact (e.g. the Razdolnaya R.), but was also observed in rather clean rivers (the Ussury and the Ussurka) though with a diminished scale. As a result annually averaged nitrate concentration in the Razdolnaya R. has reached last years the level observed in the rivers of northeastern Chinese provinces draining watersheds with intensive agriculture. The coincided increase trend of fertilizers usage at the Primorye region at the same period when the nitrate level in rivers grew supports the hypothesis about a causative link between inter annual dynamic of nitrate in rivers and agriculture activities at the watersheds.

In Japan no clear trends in the concentration of major contaminants were registered during the last decade: water quality of all first class rivers continue to be quite good. Detailed analysis of the river and direct inputs of some contaminants within one of the Japanese prefecture (Toyama) in 2012 has shown that contribution of direct input to total discharge varies according to contaminants but general contribution of direct input to the total input is approximately 10 to 20 %. As to the relative importance of contaminant sources (industrial, domestic, animal farm and non-point sources), non-point sources are most important for river discharge of BOD, COD, TN and TP. While for direct input, domestic waste is most important for BOD and TN, and non-point source is important for COD and TP. Comparing the estimated data with those of the same parameters in 2006, the present estimated load of COD, TN and TP slightly decreased although the load of BOD a little increased. The scenario for 2020 for Toyama prefecture has predicted that both river and direct input will decrease compared with the data in 2012. Extrapolation to other coastal areas of the NOWPAP region in Japan is in a decreasing trend in near future, though the additional study for other prefectures/subregions are necessary.

These inter annual variations are connected with variability of water discharge mainly. Sewage treatment rate by population increased during the decade. Decrease of population and increase of sewage treatment rate of the area are suggested to contribute to decline in the river and direct input of pollutants.

Direct inputs of contaminants as sewage outfalls to the sea have a minor quota in the balance of land-based sources of wastewaters and contaminants to the coastal sea areas within the NOWPAP region. For example, in Liaoning and Shandong provinces the volume of wastewaters discharged to the sea directly is less than 1% of gauged river runoff. The quota of contaminants delivered by direct inputs is higher, but still less than 3-4% of river runoff. Generation of wastewaters at the watershed with following release to the river network is a more large-scale source of contaminants. Some of these treated or untreated wastewaters flow to the river network through the outfalls as point sources, and others come across the relief or with storm waters as non-point sources. That is some of contaminants in river runoff can come from wastewaters, and to distinguish the source of such pollutants is not an easy task. Nevertheless even comparison of the wastewaters generation with river runoff in terms of water volume and fluxes of contaminants can give valuable information at the assessment of anthropogenic impact within different parts of the NOWPAP region.

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Assessment of trends in river and direct inputs of contaminants to the marine and coastal environment in the NOWPAP region. Regional Overview

Оценка тенденций изменения выноса загрязняющих веществ реками и сточными водами в прибрежно-морские акватории северо-западной Пацифики. Региональный обзор

На английском языке

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