**Introduction**

In terms of environmental pollution, controlling water pollution is the most important and strategic mission because water is the source of life. Contaminated water can destroy everything related to water, and even life. Therefore, conserving a clean water source is considered a critical national policy in environmental protection.

In 2015, the 132nd Inter-Parliamentary Union Assembly (IPU-132), held in Vietnam, declared Hanoi passed a resolution “Shaping the new mechanism on water governance: Promotion of Parliamentary action on water issues,” emphasized the vitality of a clean water source and considered the lack of water, along with the opportunity to contact with clean water as a threat to the development and global security. Also in 2015, two of seventeen United Nation’s sustainable development goals (SDG) relate to clean water source: SDG 6 of clean water and sanitation, and SDG 14 of protecting lives below water

Vietnam national strategy in green development period 2011-2020 and vision 2050 were approved in 2012, determining that the sustainable development goals based on the improvement of environmental quality is the work of the whole party, all national citizens, all levels of governmental authorities, enterprises as well as social organizations. Of all, improving the quality of water environment is one of the most important parts of green development basis.

With a deep awareness of the importance of controlling contaminated water to protect water resources, document “Water pollution: Current affairs, effects on health and economy” was written to provide deputies with basic information about water source, statistics of current states of contaminated water and serious impacts of water pollution on health of Vietnamese citizens and economy. Based on the information, law proposal about controlling water pollution is significantly necessary and rushed to step-by-step stop water pollution activities and gradually rebuild clean water system in our country.

# INTRODUCTION OF WATER SOURCES

**Water on the Earth**

Water is vital need for life on Earth. Human history has seen that many civilizations developed prosperously thanks to plentiful water sources and withered when water became rare.

Water is ubiquitous, on earth (ocean, lake, pond, river, and stream), on air (in form of moist, and cloud), underground (ground water), and inside living creatures. However, the actual amount of water that can be used to maintain lives of human and other animals as well plants is very small. Only 2.5% water on the Earth is fresh water. This small amount of fresh water mainly exists in form of ice or underground, and only about 1.2% fresh water is surface water used to main life. Of tiny 1.2%, most are underground permafrost, 20.9% in lakes and ponds, and only 0.49% in rivers and streams. Even though they account for small percentage, water sources in rivers, and streams are the main one that humans exploit. If the contaminated water that cannot be used is removed, this amount will be even smaller.

It is possible to demonstrate the image of water amount in the globe by imagining to culminate it as blue spheres in Figure 2. The big blue sphere is the total amount of global water, two smaller sphere is the amount of liquid fresh water and that one of fresh water in rivers, and lake. It can be seen that the amount of fresh water that is usable and easy to exploit is extremely tiny.

**Surface water and ground water**

In general, water source is divided into two groups, including water on earth (surface water) and water underground (ground water). The source of surface water is categorized into main groups as following:

* Seas and coastal areas: coastal areas contain three typical kinds, which are creeks, bays,
* Rivers, streams, canals: flowing water area
* Lakes, ponds: still water areas, including freshwater lakes and saltwater lakes
* Wetlands: as named, wetlands are the flooded areas in periods, interruption or permanent. Wetlands may consist of saltwater, brackish water, or fresh water, still or flowing in slow mode.

Ground water is water that lies under the ground, and inside rifts and gaps of soil and rock. When rainwater or surface water absorbs into the ground, one part will evaporate, some will be absorbed by plants, the rest, under the effect of gravity will continue going into the lower ground level, filling the gaps as well as rifts of soil and rock, and forming ground water.

The basic difference in geography (on earth, and under the ground) leads to the main differences of surface water and ground water as following:

* Quality difference: surface water has interactions with space, so water quality depends on many factors such as topography, soil usage, and economic development activities. Surface water, therefore, can be contaminated more easily than ground water. In addition, absorption through many ground levels helps to filter some contaminants before water enters groundwater stream.
* Ecosystem difference: surface water area is customized with a diverse ecosystem including fish, shrimp, crab, mollusk, and aquatic plants while ground level does not have. Life of human and other living creatures depends almost absolutely on aquatic ecosystem and water quality of surface water areas through drinking water, water for living, water for production, and for entertainment. Hence, health of these ecosystems has a big effect on living quality as well as sustainable economic development of human.

Because of above basic difference, controlling water pollution with regards to surface water and groundwater is also totally different. The subject of this document only limits to surface water areas.

**Ecosystem in surface water areas**

Aquatic ecosystem consists of populations of creatures that live aquatic environment and have interactions with each other as well as the environment, receive nutrition from the environment and shelter. Aquatic ecosystem includes sea ecosystem and freshwater ecosystem. Freshwater ecosystem is categorized as two main groups, which are still water ecosystem (lakes, ponds) and flowing water one (rivers, springs).

The area contiguous to river (riparian zone) has certain effects on the aquatic ecosystem. A strong riparian zone is featured with thick plant corridor that helps to prevent erosion, slow down the direct flow to river to prevent flood in downstream, filter contaminants from agricultural activities such as fertilizer, pesticide, and provide shelters and food to living creatures in river bank. Riparian zone, a connection between aquatic ecosystem and terrestrial ecosystem, protects them, stabilizes the bank, and maintain water quality. Therefore, maintaining a strong riparian zone is an important solution to ensure a health aquatic ecosystem. Figure 3 demonstrates a typical layer of ecosystem in the riverside.

**River basin**

River basin is an area in which both surface water and groundwater flow into one mainstream. Water converges into the main stream, and to waterfront or lake, which the outward point of river basin. The boundary between two river basins is determined the highest point between them. The natural features of basin and economic development activities of human on the river basin have significant impacts on the quality and quantity of water source in the basin.

**Surface water areas in Vietnam**

***River, stream, lake, pond, canal***

According to the list of inter-provincial river basins which is published by the Prime Minister Administration, our country has up to 3450 relatively big rivers and springs (the length above 10 km) [6]. Of all, 13 big river systems have basin area above 10,000 km2. Basin of 8 main river system (Hong – Thai Binh, Bang Giang – Ky Cung, Ma, Ca – La, Thu Bon, Ba, Dong Nai, Cuu Long) accounts almost 93% total area of basins in the whole country and 81.7% total country area. It can be said that majority of country area belongs to any river basin or lake basin.

According to Vietnam Environment Administration, our country has 17 big river basins (with area more than 2,500 km2) including: Cau, Ky Cung-Bang Giang, Hong-Thai Binh, Ma-Chu, Nhue-Day, Ca-La, Gianh, Huong, Thach Han, Vu Gia-Thu Bon, Tra Khuc, Kon, Se san, Sre pok, Ba, Dong Nai-Sai Gon, Cuu Long (Figure 5).

With a thick system of rivers and lakes, Vietnam has relatively plentiful water sources. However, if only domestic stream is considered in dry season, the potential to supply water in many river systems in our country is quite low (350 – 1000 m3/person.year), the country average of about 950 m3/person.year indicates that the serious scarcity of water in dry season in many places in our country. According to Falkenmark water stress index, one country or one area is regarded to have water stress if the annual water supply amount is below 1700 m3/person.year. With water supply of 1000 – 1700 m3/person.year, there is a possibility of water shortage in one period while below 1000 m3/person.year, there will be water scarcity [23]. Water scarcity, along with the growth of water pollution, in the current effect of climate change changes water distribution in both space and time, which makes meeting the water need for sustainable economic development and conservation of ecosystems in the present and future become a big challenge for Vietnam.

***Sea and coastal area***

According to United Nations Convention on the Law of Sea in 1982, one country with seaside may have the coast, such as internal waters, territorial sea, contiguous zone, exclusive economic zone and continental shelf of the connotations and different legal regimes; which, in internal waters is considered as part of the land territory of that country.

Sea area that belongs to Vietnam sovereignty is roughly one million km2 South China Sea; of all, inland water area is 4500 km2. Sea areas and shelfs in Vietnam is one part of South China Sea along with the coastal line around 3260 km, from Quang Ninh to Kien Giang, with many estuaries, lagoons, creeks, and bays. In other words, every 100 km2 land territory has one km seaside, this ratio is six times higher than the world average (600 km2 land has one km seaside) [5] (Figure 6).

Coastal area includes three typical kinds of surface water, which are creeks, bays, estuaries, and lagoons. Creeks and bays in coastal Vietnam are understood as one part of sea concaving on the continent or island shielding to create an enclosed water area. Preliminary statistics show that Vietnam coastal area has total 48 creeks, bays of total area of around 4000 km2 with different complexity and concentration levels. Although surface area of creeks and bays constitutes about 1.1% land area and roughly 0.4% sea area, they are in critical positions, which are extremely important to the development of socio-economy and security of the country [23]. Creeks and bays in coastal Vietnam associate with the development of economic and residential centers and big urban cities such as Ha Long, Da Nang, Nha Trang. Creeks and bays in conditions of low wind amount, deep water, less prone to sedimentation also have advantage to build big sea ports to develop industry and service areas. Of 15 coastal economic centers approved and founded by Prime Minister, many important areas, including Van Don, Vung Ang, Chan May – Lang Co, Dung Quat, Van Phong are all in bay banks. Creeks and bays are also traditional fishing grounds and places with high potential for growing seafood. Furthermore, creeks and bays usually have beautiful landscapes, rich and diverse biological resources, high biological activities, and specific ecosystems, so they have high values and potentials to converse nature as well as develop tourism [23]. Ha Long Bay with two recognition as world heritage in beauty and geology is a typical example.

Unfortunately, under the pressure of economics development, many shortcomings in environment management happened, especially water pollution, landscape distortion and ecological balance break. Recently, water pollution disaster in Vung Ang has caused severe influences on health, environment and economics.

***Wetlands***

There are many methods to categorize wetlands, yet wetlands all have common features, which are shallow water or saturated-water, rich nutrition source, specific ecosystem and high biological variety. Wetlands have many advantages such as maintaining and improving water quality, providing living environment to a big number of animals and plants, storing flood, maintaining stream during dry season, and supplying natural products to human. Many wetlands contain nice landscapes which promotes entertainment services and tourism.

In Vietnam, wetland is very diverse with an approximate area of 5,810,000 ha, making up around 8% total wetlands in Asia. Of all, freshwater wetland constitutes about 10% area of the whole country wetland [24]. According to Vietnam Environment Administration – Ministry of Natural Resources and Environment (2001), Vietnam currently has 68 wetlands (roughly 341,833 ha) with profound significance in biological and environmental diversity.

Ramsar Convention is an international treaty in conservation and appropriate usage of wetlands, with the aim to prevent increasing intrusion into wetlands as well as the loss of them in the present and future, recognize basic biological functions of wetlands and their values of entertainment, science, culture and economics. Until 10/2013, there are 168 member countries joining this convention, with 2,165 wetlands constituting 205,830,125 ha. Vietnam, joining Ramsar Convention in 1989, is the 50th member and the first Southeast Asia country. Currently, Vietnam has total 6 Ramsar world areas, which are Xuan Thuy National Park (Nam Dinh), Bau Sau wetland in Cat Tien National Park (Dong Nai), Ba Be Lake (Bac Kan), Tram Chim National Park (Dong Thap), Mui Ca Mau National Park, Con Dao National Park (Ba Ria – Vung Tau) [7].

# QUALITY OF SURFACE WATER IN VIETNAM

**Preword**

Clean surface water (from here we will call clean water) is defined in many ways, one of which is Federal Water Pollution Control Act: clean water has quality that is appropriate for protecting and ensuring the growth of fish, oyster, clam, mussel, and other aquatic creatures, wild animals and for human entertainment activities under and on the ground.

Water quality standards in US and other countries in the world are structured according to different usage purposes such as drinking water, water for living, water source for fish, krill (mussels, clams, snails…), water source for entertainment, sport and water source for agriculture, industry and other purposes. These standards are usually based on physical and chemical indicators expressing levels of organic material pollution (with parameters such as dissolved oxygen DO, biochemical oxygen demand BOD5, chemical oxygen demand COD) and nutrition pollution (nitrogen N (NH3 NH4+, NO2-, NO3-…), phosphorus P (PO43-...)), physical indicators (with parameters such as turbidity, total suspended solids, color,…), bacteria indicators (with parameters such as coliform indicators, *E. Coli*,…), toxic metal indicators (with parameters such as lead, mercury,…)

Quality of a basic water source must at least ensure bacteria indicators and toxic metal indicators at a very low level (even lower than maximum allowance level) or zero in order not to affect human health, aquatic creatures’ health, ecosystem health, and ensure human safety in contact with water sources.

In our country, surface water quality is categorized based on national technical standards of surface water quality – QCVN 08/2015/BTNMT (applied to surface water areas, including rivers, springs, ponds, lakes, canals) with 36 different parameters. The limited values of these parameters are divided into two types A (A1, A2) and B (B1, B2) specifically

**Box 1: Surface water standards categorized based on usage purposes (QCVN08/201-BTNMT)**

A1: Used for living activities (after applying conventional treatment), conservation of aquatic animals and plants, and other purposes

A2: Used for living activities but must be applied with appropriate technological treatment, and other purposes

B1: Used for irrigation or other purposes that requires the same water quality or other purposes

B2: Used for water transportation and other purposes with requirement of low water quality

Currently, there is no statistics for evaluation of Vietnam surface water quality before 1990s. However, earlier surface water for living and irrigation was taken directly from lakes, ponds, rivers, and springs, and there are almost no records of poisoning for fish or human in a big scale and disaster degree. Even records of poisoning for fish and human in a small scale could not virtually be found in documents.

On the other hand, rivers, ponds and lakes in Vietnam are usually the inspiration source for poem, music and art, proving beautiful landscapes and good water quality. For example, a folk saying about To Lich River in Hanoi “Nước sông Tô vừa trong vừa mát/ Em ghé thuyền đậu sát thuyền anh” (literally meaning “Water in Tô River both transparent and cool/I take my boat next to yours) or in Bac Ninh folk song about Cau River: “Xuống sông uống nước cho nguôi/Thỏa nỗi nhớ mong” (literally meaning “Going to river to drink for calming/Calm the nostalgia”), or two famous lines in poem by Te Hanh about Tra Bong River (Quang Ngai): “Quê hương tôi có con sông xanh biếc/Nước gương trong soi tóc những hàng tre…” (literally “My hometown has a transparent blue river/Clear water as mirror reflects bamboos….” Many previous water sources were so clean that people could drink water directly. For example, Bung Cu spring (Binh Duong) were formerly drank by undercover revolutionaries and the spring itself was the main food sources during the period of resistance against the US.

**Status of surface water quality in Vietnam**

Surface water quality in Vietnam has been facing severe deterioration. In 63 provinces, water pollution has been an alarming issue. According to news of pollution and environment management posted on category Environment News of Vietnam Environment Administration website from Oct 1st to November 6th, 2013, news about water pollution made up 45%. The rest is about environment management in general, solid waste pollution, dangerous waste-chemical pollution, management of land, forest and minerals, and air pollution (accounting for 55%) [32].

Surface water quality of rivers and canals, especially in urban areas and industry areas are deteriorating to the extent that it is almost transmuting and dangerous to human as well as aquatic animals and plants. In fact, To Lich River, Set River, Kim Nguu River… has become one part of sewage disposal system of Hanoi, and river water has become blank and stunk as sewage. Other rivers such as Ngu Huyen Khe River (Bac Ninh), Buoi River (Thanh Hoa), Nhue-Day River (going through Ha Tay, Ha Nam), Thi Vai River (Dong Nai), Bo Ca Spring (Son La), Da Do River (Hai Phong), Gam River (Cao Bang), Nhat Bich Tri Lake (Lang Son), Nam River (Bac Can), Ngoi Lao (Phu Tho), Na Bo Spring (Lai Chau)… are all in an alarming state of pollution, and they have recently been posted on media.

Quality of water in coastal areas is also experiencing severe deterioration: estuary of Doc River (Ca Mau), Hai Phong seaside, and specifically coastal areas in Central Vietnam. The environmental disaster in Central Coast causing massive fish death in April 2016 shows that water pollution changed water quality, ecosystem quality and participated in food chains. Usually when water quality deteriorates to that extent, recovering will be very difficult, costly and time-consuming.

Industrialization and urbanization during the past three decades have affected and polluted surface water areas, making water quality worsening on a large scale and indicating that water pollution is almost out of human control.

Report of national environment status in 2012 about water environment showed that water quality in upstream area of big rivers is relatively good. However, in downstream areas, there are places that are heavily polluted, especially urban areas, industrial areas, craft villages, mining areas. The degree of water pollution depends on a variety of factors such as hydrological flow, climate, efficiency of controlling sewage. Water environment in pond and lake systems, canals, and small rivers in central big cities are all heavily polluted. Following is status of river water quality in 12 main river basins according to report “Đánh giá những bất cập và khoảng trống pháp lý trong hệ thống văn bản pháp luật hiện nay liên quan đến kiểm soát ô nhiễm nước của bộ TN&MT” (literally “Evaluating shortcomings and legal gaps in current legal document systems related to controlling water pollution by Ministry of Natural Resources and Environment”).

*Ky Cung – Bac Giang River Basin*: In recent years, water quality in Ky Cung River has worsened significantly. Analysis results show that some physicochemical and biochemical indicators (TSS, COD, BQD5, NH4+, NO2-), toxic metal indicators (Fe, Mn), bacteria indicators (Coliforms) passed over allowances of water standards type A2, and only met the standard type B. On Hoa River, Trung River and the watershed of Thuong River, the results of water quality analysis are all in allowable limits, but the concentration of contaminants is increasing in the downstream areas where there is dense population and industrial facilities. On the other hand, on river segments going through towns and mining and mineral processing areas, physicochemical and biochemical indicators have increased and river quality has declined in recent years. Hien River and Bang River, water sources for living and production of Cao Bang town and some nearby districts, has the concentration of suspended solids 2 – 3 times higher than water standard type B1. In other rivers, this indicator is even 6-7 times higher than the standard. Ka Long River is currently polluted due to transportation activities and sewages. The segment of Ka Long River going through Mong Cai Town tends to have an increasing concentration of contaminants lowering water quality.

*Red River*: The results of environmental monitoring in the upstream area of Lai Chau Province, Lao Cai, Cao Bang, Ha Giang… show that majority of indicators are over the allowable limit of water standards type A1. The segment in Red River going through Phu Tho and Vinh Phuc has some physicochemical and biochemical indicators higher than water standard type A1. At some monitoring points on Red River close to factories and industrial production areas, the values of these indicators are even approximately equivalent to standard type B1. At some points such as monitoring point next to Viet Tri Paper Joint Stock Company, total suspended solids (TSS) are even four times higher than standard type B11. Red River water quality in Hanoi is relatively good as the values of physicochemical and biochemical indicators (DO, BOD5, and COD) are in range of allowances of surface water standards. Nevertheless, concentration of these indicators in rain season are usually higher than those in dry season, possibly due to the erosion of contaminants from the upstream areas. Compared to other rivers within the region, Red River has a much lower pollution degree. On Red River segment through Hanoi, pollution indicator is usually approximately the threshold of standard type A1.

*Cau River Basin*: Surface water quality at the watershed of Cau River is still good as all indicators meet surface water standard type A1. The middle part has had a lower pollution degree, the chemical indicator (NH4+) and total suspended solids have passed the threshold of surface water standard type A1. However, pollution tends to increase towards the direction of downstream area, especially segments of Cau River going through Thai Nguyen, Bac Giang Province, Bac Ninh Province and heavy pollution at Ngu Huyen Khe River, Bac Ninh Province. Pollution of surface water in the downstream area through Bac Giang Province, Bac Ninh Province is still increasing; specifically, some physicochemical and biochemical indicators are over the threshold of surface water standard type B1 (COD and TSS). Only parameter (NH4+) has the sign of gradual decline from 2007 until now. The water quality of Ngu Huyen Khe River has an increasing pollution, and no sign of improvement. Ngu Huyen Khe River water is contaminated with organic chemicals and suspended materials, whose concentrations are ten to hundreds of times higher than surface water standard type A2, depending on time of the day.

*Nhue – Day River Basin*: Surface water environment of Nhue – Day River basin was strongly affected by sewage from living activities, industrial and agricultural activities within the region. Water quality in many segments is polluted to the alarming extent. In dry season, the values of some physicochemical and biochemical parameters (BOD5, COD, TSS…) at some points are many times higher than the allowable limits of standard type A1.

Nhue River: At the watershed (after water from Red River arrives), river water is almost not polluted. Nhue River water at places that do not have industrial areas or residential areas has a relatively good quality, especially during rainy season. At some points, water has a low contamination level thanks to self-cleaning process of the river, and the concentration of contaminants decrease. However, Nhue River water is severely contaminated at the intersection with To Lich River, places with industrial areas such as the joint stream of To Lich River and Nhue River (Thanh Liet dam), which has dramatical increase in the concentration of contaminants in Nhue River. All monitoring indicators have values over surface water standard type B.

Day River: Day River water and other rivers have a lower level of pollution in comparison with Nhue River, and pollution only happens at certain parts. Closer to downstream area, contamination on Day River tends to decrease. Because of the dilution of the sewage from upstream area and self-cleaning process of the river, the water quality in downstream area of Day River (from Kim Son – Ninh Binh to the entry of Day) is much improved compared to other parts.

Rivers going through center of Hanoi receives and conducts all kinds of sewage so pollution becomes extremely severe and changes continuously depending on time of the day. Indicators are all many times higher than surface water standard type B1, even over sewage standard (QCVN 14:2008.)

Thai Binh River system: Water quality of Thai Binh River system, which goes through Hai Duong Province, is relatively fresh. Nevertheless, indicators are approximately equal to or even over the surface water standard type A1. On Thai Binh River, concentration of contaminants in water source that receives sewage from Long Hau River, Kien Giang, some physicochemical-biochemical indicators (COD, BOD5, SS, mineral oil), bacteria (coliform) are over the allowable limits of standard type A1. In addition, there are some water sample contaminated with arsenic, cadmium.

*Ma River basin:* On Ma River, Chu River, values of biochemical indicators (COD, BOD5), and bacteria (Coliform) in general meet water standard type A1. Total suspended solids (TSS) is mostly over the water standard type B1, water color is usually cloudy red. Values of TSS on Ma River have had the increasing trend recently. Meanwhile on Chu River, the trend is decreasing. The explanation is the high amount of alluvium on Ma River or erosion in upstream area.

*Huong River (Thua Thien Hue):* Huong River water is relatively good; values of monitoring indicators meet the surface water quality. Water could be used for living activities after treatment and other purposes (A2, B1). Upstream area of Huong River has relatively fresh water (meet the threshold of standard type A1). The segment through Hue city (from Long Tho wharf to freezing factory) has biochemical indicator value (BOD5) higher than that in other point due to the influence of sewage.

*Vu Gia – Thu Bon River basin (Da Nang – Quang Nam)*: Water quality at Vu Gia River basin is contaminated with organic chemicals, and total suspended solid is relatively high in monitoring points. Biochemical indicators (BOD5 and COD) are over standard type A2. Water in Thu Bon River basin is in a relatively good quality. All biochemical indicators (BOD5, COD) meets the surface water standard type A1, which is usable for living activities.

*Tra Bong, Tra Khuc River basin (Quang Ngai):* Surface water on Tra Bong – Tra Khuc River basin is polluted with organic chemicals. Biochemical indicators (BOD5 and COD) are higher than surface water standard type B1. However, pollution level at this river basin is declining over time.

Kon River basin, Ha Thanh River basin (Binh Dinh): Water on Kon River basin encounters organic pollution. Biochemical indicators (BOD5 and COD) in most monitoring points are over surface water standard type A1, in some places are over standard type B1 (mostly on months of dry season). Water quality of Ha Thanh River basin is relatively good. Most of biochemical indicators (BOD5 and COD) are equivalent to or slightly higher than water standard type A1.

*Dong Nai River basin*: Upstream area of Dong Nai River which starts from Lam Dong Province is in a comparatively good quality. This area, despite barely affected by industrial waste, experience erosion of alluvium during rainy season, which changes the water quality. The distributaries on Dong Nai River, which belongs to Be River, La Nga, have relatively good water quality; most of them are under type A2 according to surface water quality.

The segment through Bien Hoa city of Dong Nai River and tributaries, distributaries: Water within this region experiences the most severe pollution on Dong Nai River. On the middle part of Dong Nai River, level of nutrition pollution is relatively high as the concentration of nitrogen (NH4+) in all monitoring points are over allowable limits of surface water standard type A1. Specifically, at Ong Buong Bridge, values of indicators are always high in many years. Bacteria pollution level is increasing from the middle part to downstream are of Dong Nai River.

*Sai Gon River*: one of the biggest tributaries on Dong Nai River. Water on upstream are of Sai Gon River is still good, but downstream area has sign of organic pollution, especially Ho Chi Minh City (Sai Gon Bridge to Y-shaped Bridge). Biochemical indicators (BOD5, COD) and other bacteria do not meet standard type A2, even in many points pass standard type B1.

*Thi Vai River*: On Thi Vai River, efforts of preventing pollution show positive results that some severe pollution places have recovered. Analysis results reveal that water quality meets standard type A2 (QCVN 08:2008). However, there appears pollution in certain places and solution to over them (some companies and industrial areas).

*Tien River and Hau River*: In recent years, on Tien River, there has been an increase in acid concentration. Nonetheless, recorded values are within the allowable limits. During rainy season, spreading alum phenomenon makes many places of middle part and downstream area of Tien River have pH lower than those of upstream area. During dry season, pH value is fairly high (pH ≥ 7,5) on some points on upstream area of Tien River.

Hau River has heavy water flow (especially during rainy season), and broad and deep river bed, which significantly prevents pollution coming from economic development activities. Therefore, monitoring result shows that biochemical indicators (COD, BOD5) are quite low, and most meet water quality type A2. Level of organic pollution on Tien River is higher than that on Hau River. Most of biochemical indicators (COD and BOD5), recorded during 2008-2009, were over surface water standard type A2. However, in recent years, pollution level has decreased significantly. On monitoring points, biochemical indicator (BOD5) is below standard type A1 and usable for living activities.

Monitoring analysis at Long Binh (An Giang) on the watershed of Tien River. During rainy season (May to October), diluted oxygen value (DO) meets surface water standard type A1. Meanwhile, during dry season (November to April), diluted oxygen value (DO) is very low and fluctuating, even there is time that it does not meet minimum of standard type B2.

*Vam Co River*: Physicochemical and biochemical indicators, bacteria (pH, DO, COD, BOD­5, NH4+, Coliform tổng) all fluctuate and pass above surface water standard type B1.

Water source of Vam Co Dong River has a fluctuating pollution level and does not meet surface water standard type A2. Vam Co Dong River water has not showed a decreasing pollution level. At draining positions, there is tendency of decline, but indicators are still many times higher than allowances. However, besides draining points, the overall water quality meets the standards, indicating that Vam Co Dong River has effective self-cleaning process.

Vam Co Tay River is less alum-contaminated than Vam Co Dong River. Parameters are above the allowable limits, yet pollution level is not as high as that in Vam Co Dong River. Pollution indicators have values that are higher than surface water standard type A2. In general, Vam Co Tay River is less contaminated than Vam Co Dong River [3, 4, 10].

# MAIN POLLUTION SOURCES

Pollution sources are categorized into two main groups based on location and scale. They are point pollution source and area contamination source.

Point pollution source are a single source that can be determined, such as sewage pipes. For example, factories, water treatment facilities of the city are points of pollution source.

Area pollution source contain rainy water overflowing or underground. During overflowing process, water brings natural contaminants and human made to surface water areas such as rivers, lakes, ponds, canals and coastal areas. For instance, pesticides, chemical fertilizers from agricultural lands and residential areas, toxic oil chemicals in rain, livestock wastes, septic tanks…

**Point pollution sources**

***Factories and industrial areas***

To develop economy, Vietnam is striving to attract more foreign investment and encourage domestic investment in industrial fields. However, the bad side is environmental pollution, especially surface water pollution due to direct draining of untreated or not completely treated sewages. Sewages of agricultural production have different compositions depending on production field, for example, water disposal of food processing, paper is mainly organic materials; sewages of metallurgy, steel production, chemicals, textile… are toxic metals/toxic compounds.

With regards to textile factories, paper and paper powder production factory, sewage usually has average pH of 9-11 (alkaline), biochemical oxygen demand (BOD5), chemical oxygen demand could reach up to 700 mg/l and 2,500 mg/l, 7-14 times higher than sewage standards of paper and textile industry (QCVN12/2008-BTNMT for paper industry, QCVN13:2008/BTNMT for textile industry), total suspended solid (TSS) is much higher than allowable limit. Concentration of cyanide (CN-) in sewage of textile industry is 84 times higher than allowable standard, which pollute seriously surface water.

Furthermore, chemical factories contribute significantly to pollution sources of water environment. After analysis and evaluation of Vietnam Chemicals Agency - Ministry of Industry and Trade, majority of basic inorganic chemical production facilities (acid, base..) is in out of date and low technology which was supported by Soviet and China almost 50 years ago. Therefore, these facilities also produce a large amount of sewage with indicators many times higher than allowable limits. New chemical factories with modern technology still cannot avoid draining sewage, which pollutes water source of the region, specifically Ninh Binh fertilizer factory. [16]

**Box 2: Environmental issue at Ninh Binh Fertilizer Factory[16]**

According to report by Do Xuan Sinh in Yen Khang Town, Y Yen, Nam Dinh Province: “Inhabitants were all affected, experienced tinnitus during production; stench of protein transmits nearby area. Currently, there are two draining pipes to the river, causing massive fish death on the riverside. Hao Phu village, Khanh Phu commune, Ninh Binh Province was most severely affected by this factory”

According to Department of Natural Resources and Environment Ninh Binh Province, last year the factory leaked a concentrated amount of ammonium (NH3) to the canal, causing the death of fish and three cows. The reason is that the factory drained the sewage to Day River with a concentration of ammonium and phosphorus 50 – 179 higher than the allowable limits. Ms. Pham Thi Doan, Khanh Phu commune, Yen Khanh, Ninh Binh said: “If you do not clean the environment now for us, the company should close.”

According to Environment Protection Law (2005), all production projects must complete all investment and environment treatment categories as well as evaluate the effects on environment before official operation. However, Ninh Binh fertilizer factory, despite incomplete work, has operated for more than a year.

Industrial Management Committee of Ninh Binh Province reported that during the first six months in 2013, Ninh Binh fertilizer factory within Khanh Phu industry area caused bad affairs affecting the environment three times. On 7th May, sewage within the factory area drained to Chanh River and caused fish death.

Regarding industry area, of 6 economics regions throughout the country, Southeastern part (including all provinces in the southern key economic hub of the country’s major industrial zones) has the highest unexpected industrial sewage in the country, constituting 50%.

According to statistics recorded until June 2015 by Vietnam Environment Administration – Ministry of Natural Resource and Environment, of all industrial zones currently operating in the country, 89% of them has had building focused sewage treatment system, and 11% has not done and has discharged directly outside without proper treatment. Unfortunately, approximately 70% total unexpected sewage is estimated to be discharged directly outside without treatment.

In addition, enterprises which are not within industrial zones have built sewage treatment system, but they almost do not operate or operate ineffectively or deteriorate.

Current states lead to the fact that a huge amount of sewages from industrial zones, when discharged to the environment, has pollution indicators many times higher than allowable limits, specifically total suspended solid, nutrition concentration, coliform concentration (factor causing effect on health such as disease, …) in some places are 4500 to 210000 times greater than the allowable limits for industrial sewages (QCVN 40:2011/BTNMT)

**Box 3: Statistics of pollution due to industrial production in Thai Nguyen**

According to preliminary statistics by Department of Natural Resources and Environment Thai Nguyen Province (2014), every year industrial production facilities discharge around 19 million m3 of sewage/year, and this number is estimated to grow 22% each year. Of 100 facilities that cause environmental pollution on the province, there are 54 facilities containing sewage source that damages environment severely. During annual inspection, it was detected that some units discharged sewages that have indicators much higher than standard. Many analytical results of surface water samples on the streams receiving sewages from mines and industrial production base, show signs of pollution: suspended solids (SS) and some heavy metals: Cd , Pb, Zn, Fe exceeded the national technical standards for the quality of surface water dozens of times; many groundwater samples have pH, Cd, Mn that exceeded the national technical standard of groundwater quality from 1.2 to 1.96 times; waste water samples had levels of heavy metals and suspended solids exceeded environmental standards of waste water hundreds of times.

*Source: Le Trinh, Report at National Environment Conference 2015*

***Craft village***

Craft village is a feature of rural Vietnam, as there is no other country in the world where rural areas have large density of craft villages with plentiful and diverse non-agricultural production. Basically, craft village is a collection of many households/small business and that manufacture same business sectors/commodities. Much of craft villages have a long tradition (silk, rattan, food processing ...), others are new villages arise due to the actual needs of society (paper recycling, plastic, metal recycling ...).

Currently, according to statistics until 2014, there are 5096 craft villages. Off all, the number of traditional village which is recognized today is 1,748 villages. The villages are primarily located in the Red River Delta (> 50%), North Central and Central Coast is 25% .... According to a survey from the craft villages, on average, 15,000 m3 of waste water that is mainly untreated daily discharged directly into the canals, ponds and neighborhood area (*Source: Dang Kim Chi, Report at National Environment Conference 201*5).

Volume and characteristics of waste water produced from the craft village depends mostly on technology and raw materials used in production. Food processing, livestock breeding, livestock slaughtering, dyeing ... are industries that have huge water usage and discharge large volumes of sewage with high level of organic pollution. On the other hand, some sectors such as recycling, metal processing, bronze casting ...do not need to use too much water, but the waste water contains very harmful ingredients such as acids, chemicals, metal salts, cyanide and heavy metals. Depending on the type of craft villages and water pollution are classified as follows [3.4]:

1. Organic pollution in craft villages that focus on food processing, food, farming and slaughtering. This is the type of production that needs huge water usage, and waste water has a very high level of organic pollution. Levels of organic pollutants/nutrition are expressed by parameters COD and BOD5, SS, total N, total P exceeded allowable regulations up to ten times. Particularly, sewages from the stage of separating residues, separating black powder of starch production from cassava and arrowroot have low pH, and concentrations of BOD5, COD exceed 200 times.
2. Inorganic pollution mainly concentrated on craft villages focusing on textile dyeing, handicraft and rattan, paper recycling. Sewages containing a large amount of sediments and many contaminants such as solvents, surplus of chemicals in the process of dyeing, and polishing. Textile waste water which contains many chemicals and has very strong color could have indicator value of up to 13,000 (Pt-Co), nearly 87 times higher than allowable standard (QCVN13: 2008 / BTNMT for textile waste water)
3. Heavy metal pollution, waste oil from sewage of craft villages focusing on plating, metal recycling ... The silvering also form salts of mercury cyanide, metal oxide, compounds of chromium Cr6 + and other substances exceeding waste water allowable standards from 1.5 -10 times.

**Box 4: Example of pollution in craft villages occurring in some provinces such as Bac Giang, Bac Ninh**

Only more than 880 families making wine in Van Ha (Bac Giang) and breeding 15,000 to 20,000 pigs discharge about 1,500 m3 unexpected sewage, nearly 100m3 waste that is mainly livestock manure and is poured directly out sewers, lakes. This makes pollutants concentration in the surface waters exceed the surface water standards type B1 many times: BOD5 8-10 times, ammonium from 34- 96 times.

In Phong Khe commune and paper production area Phu Lam, Tien Son (Bac Ninh), there are nearly 100 small enterprises and 70 small factories, producing daily more than 3000 m3 of waste water containing toxic chemicals such as caustic soda, detergents, double alum, rosin, javen, ligin, pastel, and so on. The segment of Cau River that flows through the boundaries of Bac Giang, Bac Ninh between Viet Yen and Yen Phong district was seriously polluted, the river water contains stench after two-hour sampling.

*Source: Report National Environment 2012 – Surface water environment*

***Cites and urban areas***

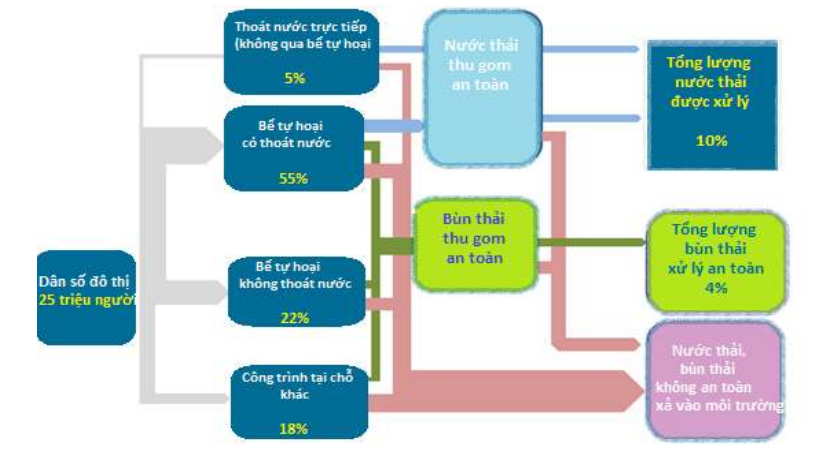
The amount of waste water flowing into the river annually is increasing due to fast urbanization. Domestic sewage accounts for over 30% of the total amount of directly discharged waste into rivers and lakes, or canals going to rivers. Calculations show that the South East and the Red River Delta are two regions that concentrates the largest amount of waste water in the country. [9]

According to 2009 statistics, the amount of waste water generated from the 3 major cities of our country is quite large and keeps increasing in the coming years namely:

|  |  |
| --- | --- |
| Cities | Total sewage (m3/day) in 2009 |
| Hà Nội | 793 207 |
| Hải Phòng | 255 988 |
| Hồ Chí Minh | 876 170 |

*Source: PCD project for building the waste water pollution control action plan in Hanoi, Hai Phong, Ho Chi Minh city*

Statistics from the World Bank also reveal that, as of 2012, about 90% of domestic waste water in urban areas of Vietnam discharged into the environment without treatment (*Figure* *9*). Largely in the urban areas, sewage is treated through the preliminary septic tank, then through the sewers discharged directly into the environment. This is the basic cause of the pollution of the rivers/canals/lakes in urban areas in Vietnam, affecting the landscape and living environment quality, upsetting people but it has not yet fully been resolved.



**Figure 9: The status of the management of urban waste water in Vietnam**

*Source: Report of World Bank, 2012*

As domestic waste water seriously pollutes surface waters in urban areas/densely populated cities, the city administration has been constructing focused sewage treatment plants. However, in fact in the country there are only 29 sewage treatment plants that are operating and concentrate on the urban centers type III or higher, such as Hanoi, HCM City, Quang Ninh, Da Nang, .... About 44 concentrated waste water treatment stations with capacity of 1.6 million m3/day have been designing and building with ODA from German, Japan, etc (Hanoi., HCMC, Hue, Vinh, Can Tho, ...) [3,4,9]. Thus, the construction of the waste water treatment plant has not yet met the treatment for sewage generated in the country in urban areas/cities, and waste water in Vietnam is still a source causing significant pollution of surface waters. Currently, there are over 774 cities, including 2 cities special type, 15 type I, 14 type II, 53 type III and 65 type IV and the rest is urban cities type V; of all, about 100 urban cities are important socio-economic centers of the region. Urbanization ratio averages about 35%. And the urban population is predicted to be 35 million people in 2015 (38% of the national population), 52 million people in 2025 (about 50% of the national population), to have the average population growth of 1.71%/year within ten years [3,4,9]. Thus, the urban population tends to increase in the future, which leads to significant increase in generated sewage amount. As a result, the pollution of surface water around the cities/urban areas will become more severe in the future if there are still no effective control solutions.

**Area pollution sources**

Area pollution sources, including rainwater runoff or groundwater flow during runoff, carry pollutants from the nature and human activities to the surface waters flowing like rivers, canals, lakes, and coastal waters. For example, excess from pesticides, chemical fertilizers from agricultural lands and residential areas, types of grease, and toxic chemicals in urban rainwater, unfocused animal waste, septic tanks, mining operations, ...

***Excess of pesticides, chemical fertilizers from agricultural lands and residential areas***

The agricultural activities (planting, cultivation of crops) always need to use large quantities of pesticides and different fertilizers. Fertilizer is partly absorbed into plant and used as nutrients, yet the rest contains large amounts of nitrogen, phosphorous, potassium, etc., which will be washed into rivers and canals. However, with regards to relatively toxic plant protection drugs, they partially evaporate, and the rest is washed out by rain water and flows into surface waters. Similarly, the pollutants from oils of vehicles on roads are often carried with rainwater into water sources. Unfocused livestock waste, and water from septic tanks are also easily washed out by rain water into the canals. These are difficult-to-control sources of pollution.

For example, according to the report “*Đánh giá tình hình ô nhiễm nước Việt nam hiện nay trong bối cảnh có nhiều văn bản quy phạm pháp luật điều chỉnh về kiểm soát ô nhiễm nước*” (literally “Assessment of the current water pollution situation in Vietnam amid many legal documents about adjustment of the water pollution control”), the number of imported plant protection products was 20,000 tons in 2005 to nearly 50,000 tons in 2014. The country has about 20,000 agents selling plant protection drugs, 97 drug processing factories with about 30000-40000 tons/year. Along with that, the amount of fertilizer also increased significantly. From 1985 to date, the amount of fertilizer consumption has increased by 500%. Vietnam currently uses about 10 million tons of fertilizers per year. The survey of the Organization for Food and Agriculture of the United Nations (FAO) showed that fertilizer use efficiency in Vietnam only reached 45-50%. That means farmers every 100 kg urea fertilizer or NPK goes into the soil, only 45-50 kg of fertilizer is absorbed by plants and produces agricultural products for planting purposes. Amount of washed fertilizer that tree could not be absorbed, is environmental pollution cause. Water environment, unfortunately is the most susceptible.

Regarding livestock sector, there is about 73 million tons of waste annually. Household farmers still account for a large proportion, so the handling and management of livestock wastes are increasingly difficult. There are 8.5 million family size farms, 18,000 concentrated farms, yet only 8.7% of households has constructed of biogas system. The proportion of households with hygienic and clean livestock cages makes up only 10% of households, and only 0.6% is committed to protect the environment. Still about 23% of households do not treat wastes with any method, but discharge directly into the surface water source (canal/ditches/lake etc.) in the region, causing severe pollution of surface water sources. In the pig farms on an industrial scale, the problem of environmental pollution caused by solid waste, sewage has been causing surface water pollution seriously. Analysis of 134 water samples taken from wells near graves of dead poultry detected 23% of the samples contaminated with organic substances exceeding the permitted level; 42.3% samples having microbial contamination exceeded the allowed limit.

With regards to aquaculture sector, one of the strongest fields of agricultural production in Vietnam, there emerges issues in aquaculture environment, which is the focused area of ​​shrimp and catfish. To have the finished one-kg fish, farmers must use 3-5kg of food, but only about 17% of fish food is absorbed, and the rest is mixed into the water. This is the organic source that is susceptible to be wasted and flow to surface water systems, so contributes to the pollution of surface waters. Waste in aquaculture is sludge containing waste of aquatic species, excess of decomposing food, the residues of used materials, such as chemicals, lime, minerals, sulfur deposition and son on. During the process of changing water, pollution sources will spill out of the waters into surrounding local areas and cause serious pollution of surface water. [3,4]

***Mining Operation***

For mining and mineral processing, water is used in large quantities for most production processes. Manufacturing process, dry off the mine, ore, waste dump ... incurred a large amount of waste water spilled on the mining site to the surrounding waters, which have caused negative impacts on quality of surface water serving agricultural production. Specifically, mining alters terrain, surface water systems, storage and drainage conditions (mechanical action), thereby changing the physical properties, chemical composition of water. In other words, it degrades the quality of surface waters flowing through the area.

Surface waters in the coal mines often have high levels of heavy metal ions, metals, organic compounds, radioactive elements etc., higher than those in surface waters and sea areas without mines higher coal and 1-3 times higher than regulation of surface water. In tin mining areas, the main manifestation of the polluted surface waters is turbid water by suspended mud - clay, increase in the amount of iron ions and some heavy minerals. The gold mining and refining ore require chemicals that contain mercury (Hg), cyanide (CN-) etc. In addition, the chemical elements such as arsenic, antimony, sulfide ores can be dissolved into the water.

**Box 5: Mineral mining gold in Van Ban - Lao Cai and Na Ri - Bac Kan [16]**

**In gold mining areas in Van Ban - Lao Cai**, the analysis of mineral water samples showed no sign of contamination of heavy metals in water. In some samples, heavy metal content is higher than allowable standards. In particular, concentration of As (arsenic) is from 15,31.10-3 mg/l to 37,34.10-3 mg/l, 1.5 – 3.7 times higher than surface water standards (type A1), which is is 0.01 mg/l. Pb (Lead) concentration levels are from 24,88.10-3 mg/l to 57,11.10-3 mg/l, 1.2 to 2.8 times higher than the surface water standards (type A1), which is 0.02 mg/l; Cr6 + content (chromium) at two sampling locations has 1.2 to 1.5 times higher concentrations than the surface water standards (column A1). Content of Hg (mercury) in area Chan stream, Nam Xe commune has concentrations 1.3 times higher than NTR; Concentration of total suspended solids (TSS) at the sampling locations is 1.1 to 3 times higher than the surface water standards. (*Statistics of environmental measurements by Trung tâm Dữ liệu và Hỗ trợ ứng phó sự cố hóa chất CECHEDAR August 2012*)

The cause of turbid and heavy metal contaminated spring water is: The illegal activity of mining sand, gravel, and placer gold on the upstream side in the Green Forest, Cot Co, Nam Xe. They built an tank to impound clean water, day and night flushing toxic chemicals to filter gold, which contaminated the stream bottom. Operating surreptitiously or without following the technical process, environmental protection and recovering solution even alters the flow of the streams Chan, Nam Xay Luong stream and Ngoi Nhu; some areas occurs stream bank erosion, causing significant impact on the infrastructure facilities, land, etc. especially in the rainy season.

**In the mining area in Na Ri - Bac Kan**, sewage that mainly comes from the ore mining, ore sorting technology is discharged into the lake about 327 600 m3/year and 10% of the ore-bearing sands and soil is carried with waste water (sludge approximately 5,460 m3/year). Waste water is produced by gravity recruitment process, so should have no harmful chemicals. The entire amount of waste water flowing into the sludge reservoir at this sorting factory. The analysis results of water samples in 2013 showed that the surface water project area has manifestations of iron contamination; concentration of total suspended solids (TSS), dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD5) do not meet surface water standards.

# EFFECTS AND DAMAGES CAUSED BY WATER POLLUTION ON ECONOMY

The main problem caused by water pollution is that it kills all life depends on water. Fish, shrimp, mollusks, birds as well as animals who live at the riverside, and the coast can be killed by contaminants in their residence. Water pollution disrupts the natural food chain, destroys the ecosystem structure, and causes the disease to humans.

Therefore, in environmental protection, water pollution control is regarded as the most important problem in advanced countries like the US, Japan, Singapore, Germany, South Korea, ...

First, this chapter examines the damage caused by water pollution, effects on human life, including the loss of fisheries resources, agricultural production, service and tourism activities.

**Damages caused by water pollution to aquaculture**

**Box 6: Pollution caused by sewage leads to tons of fish die-off on the Buoi river basin - Thanh Hoa province**

On 4th May, 2016, on the Buoi River bordered to An Nghia commune, Lac Son district, Hoa Binh province downstream to Thach Lam commune, Thach Thanh district, Thanh Hoa province, there appears the phenomenon of black color change in river water, sparkling foam, stench and signs massive fish death on the river. On 6th May, 2016, fish raised by local people continuously died, causing serious damages. As of the date of 07.05.2016, the total number of dead cage fish is over 17 tons - with the current market price of 100,000 VND/kg, the estimated loss is 17 billion dong.

The cause of the phenomenon of mass mortalities is Buoi river water contaminated with untreated sewage of 3 units, which are Tan Hieu Company, Hoa Binh Sugar Company and a pig breeding facility. On 18th May, Ministry of Natural Resources andEnvironment issued decision on administrative sanctions to 3 units because of waste discharge without treatment to Buoi River with total fines over 3,9 billion. Besides the sanctions, the Ministry also imposed additional sanctions which were temporary suspension of operations from 3 to 12 months for violating companies.

*Source: Internet*

The impact of polluted water on aquaculture is huge because water is the habitat of aquatic flora and fauna, . Water environment pollution will influence directly farmed aquaculture species for toxicity or lack of oxygen, which eventually leads to death, making them weak or arising diseases, anorexia, and slow growth; aquatic product quality deteriorates due to the composition of substances in the polluted environment (*Diagram 1*).

**POLLUTED WATER ENVIRONMENT**

Dead species

Infected species

Species do not eat or grow slowly

Species are not guaranteed with food safety

**Diagram 1. Effects of polluted water on aquaculture [25]**

For aquaculture operations, the polluted water will cause many difficulties for production activities, which are: increased investment costs of infrastructure systems of sedimentation, filtration and water treatment before water is put into the pond; increased investment costs for the use of chemicals, biological products to improve the environment; slow growths of shrimp, fish farming lead to longer time and increase in production costs, such as food, water fan operation, aeration, water pump replacement; increased production costs through the use of drugs and chemicals for fish disease prevention; reduced production efficiency due to the high mortality rate and reduced competitiveness of the market and price because the quality of fish does not meet the requirements and demands of the market, etc. (*Diagram 2)*

Reduced price and production effciency

Reduced competitiveness

Product quality decrease

Use of antibiotics, increased production cost

Infection rate

Reduced productivity, output, production efficiency

Increased production cost

High mortality rate

Increased risk

Slow growth of fish and prawn, longer time for raising

Increased production cost

Usage of medicine, chemical and bioproduct to clean water

Increased production cost

Investment in pond system, filtration tank

**POLLUTED WATER ENVIRONMENT**

Reduced price and production effciency

Reduced competitiveness

Product quality decrease

Use of antibiotics, increased production cost

Infection rate

Reduced productivity, output, production efficiency

Increased production cost

High mortality rate

Increased risk

Slow growth of fish and prawn, longer time for raising

Increased production cost

Usage of medicine, chemical and bioproduct to clean water

Increased production cost

Investment in pond system, filtration tank

**POLLUTED WATER ENVIRONMENT**

Reduced price and production effciency

Reduced competitiveness

Product quality decrease

Use of antibiotics, increased production cost

Infection rate

Reduced productivity, output, production efficiency

Increased production cost

High mortality rate

Increased risk

Slow growth of fish and prawn, longer time for raising

Increased production cost

Usage of medicine, chemical and bioproduct to clean water

Increased production cost

Investment in pond system, filtration tank

**POLLUTED WATER ENVIRONMENT**

**Diagram 2. Effects of polluted water on aquaculture [25]**

The damage extent of aquaculture operations depends on the level of water pollution. Light pollution probably decrease only production efficiency, and reduce profitability; pollution at higher levels can lead to a loss in production due to low yield, low price, ...; Serious pollution levels can lead to death squads, up to 100% damage, not only fishermen but also possibily large farming areas.

Besides the environmental pollution levels that can affect production efficiency, the qualifications and knowledge of aquaculture can have great influence on the extent of damage. The application of science and technology in water pollution processing in aquaculture will help to minimize the damages that may occur.

In fact, the planned areas of focused aquaculture have water sources in good quality and quantity for mass production; however, river systems usually have large basins and many economic sectors operating in this basin, each operation that contributes an only small part of the polluting factors can cause water pollution in downstream area and have impacts on aquaculture activities. Furthermore, other incidents such as oil spills, floods cause water pollution as well as have risk of affecting aquaculture areas.

According to Diagram 2, preliminary calculations of possible extent of damage caused by water pollution based on the cost structure of a number of species have been determined in a number of research papers in recent years. However, the data are for reference only, and there is a need of full system assessment to determine damage levels caused by water pollution for each farming area and each species. Below is estimated damages of some fish species constituting huge production proportion in aquaculture sector of Vietnam.

***Estimates of damage caused by water pollution to catfish***

It is unable to determine the extent of damage caused by environmental pollution for catfish farming correctly, yet the environmental pollution has a direct impact on the production through increased investment costs (medication, chemical, etc.), increased mortality, loss, decrease in quality of commercial fish as well as reduced price and competitiveness. According to some studies on fish by Nguyen Van Thuan and Vo Thanh Danh (2010) about the cost structure of catfish in the Mekong Delta, food accounted for 86%; species 6%; aquatic veterinary medicine 2.5%; 0.7% fuel; labor 2%; pond innovation 0.4%; 1.1% interest; depreciation of 0.7% and other expenses by 0.3%. If fuel costs increase from 0.7% to 1.0% due to pump more water due to water pollution, each 1kg fish will have price increased by 50 dong. If veterinary medicine and water treatment chemical inputs increase from 2.5% to 3.0% due to contaminated water and more arising disease, each 1 kg of fish will have an increase in price by 85 dong. Thus excluding the loss rate as well as reduced quality of fish and price, each 1 kg fish will have to incur additional costs by 135 dong due to polluted environment. With a current output of 1.2 million tons, this cost will reach up to 162 billion dong. [25]

***Estimates of damage caused by water pollution to whiteleg shrimp***

Similar to catfish, total damages caused by water pollution for all whiteleg shrimp farming areas throughout the country could not be determined exactly, so only the relative calculation based on the previous study about structural cost of farmed whiteleg shrimp. According to research by Truong Huyen Tran (2014) about evaluation of the economic and technical efficiency of tiger prawn and whiteleg shrimp raised in Long Phu, Soc Trang, the cost structure of whiteleg shrimp were identified: food cost 51%; species cost accounted for 16%; medicine and chemical costs, accounting for 5% and other expenses 28% (labor, interest rates, depreciation, ...). Expenses for environmental remediation, water treatment and epidemic prevention will increase when there are environment pollution signs, the cost could rise from 5% to 6% in the production process, meaning increased 750 VND for each kilogram of shrimp products. Thus with current whiteleg shrimp production of over 400 thousand tons, additional costs due to environmental pollution will be 300 billion dong. [25]

***Estimates of damage caused by water pollution to tiger prawn***

Like whiteleg shrimp and catfish, prawn farmers have to increase costs for the input water treatment and epidemic prevention and treatment during raising when external sources of water is contaminated. The cost increase depends on the level of pollution of the aquatic environment. In addition, environmental pollution makes water shrimp farmers suffer a lot of other risks in price, the market, etc. According to research by Truong Huyen Tran (2014) about evaluation of the economic and technical efficiency of tiger prawn and white shrimp raised in Long Phu, Soc Trang, the price structure of prawn is as following: food accounts for 60%; breeds accounted for 7%; medicines, chemicals 12%, and other costs (bank interest, depreciation, labor, ....) accounted for 21%. Thus a small increase in medicines, chemicals cost from 12% to 13% leads to an additional cost of 1,500 dong in each 1kg shrimp finished product. With tiger prawn production of 200,000 tons at present, the costs due to environmental pollution will be 300 billion dong. [25]

***Estimates of damage caused by water pollution to krill***

The costs of raising clam mainly lie in breed costs, labor and management clam area. Clam raised in intertidal area is directly affected by polluted water flowing through the estuary and influenced directly from offshore activities such as tourism, mining production, shipping, etc. Every year, clam area affected by environmental pollution, disease, non-guaranteed breed quality, raising technical errors (too thick), etc. ranges from 10-12%. Therefore, the preliminary damage by environmental pollution could be determined as follows: clams on the market price of 28,000 VND/kg. Damage by 10% is equivalent to about 18,000 tons. The value of damage is: 504 billion dong. [25]

***Estimates of damage caused by water pollution to other objects***

Besides the main objects with large volumes damaged by polluted water, other objects such as traditional fish, giant freshwater prawn, tilapia, lobster are also affected and heavily damaged because of contaminated water. Many products were completely lost due to contaminated water sources, especially the farming areas near the industrial zones, big cities where the risk of water pollution are huge and permanent.

Statistics of mass mortality of fish and prawn due to bad water quality and diseases on a number of research papers and on the media since 2010 - beginning of 2016 showed that the total funding for loss and damage were up to 1042 billion dong [22]. Thus the average annual damage for fisheries is around 160.3 billion. This number is only the tip of the iceberg, because certainly there will be more environmental issues that were not recorded.

**Damages caused by water pollution to agriculture**

According to a summary of the situation of water pollution that affects agricultural productivity and product quality by Vu Duong Quynh [22], different levels of pollution lead to different agricultural production. In less polluted places, productivity fell by 20%, while in more polluted ones, yield was reduced by 70, 80%. When there is no pollution, the fields can yield 6-8 tons/ha, but when there is, productivity is only 1 - 1.4 tons/ha. There are places with new cultivation, rice turns yellow and withers after few week; in some areas, rice is still developing but when it closes to harvest, it turns yellow, leaves are dried and then dead or rice is flowering but not ripe. Farmers harvest this kind of rice to feed animal, but even animals could not eat it. Therefore, many people are not planting more; people's lives and incomes are affected, causing serious damage to the agricultural sector. Land is contaminated, agricultural land decreased, crop yields are lowered, rice tree easily falls and produces tiny seeds.

For example, in Hung Long and Di Su, My Hao district, Hung Yen, rice area has been affected by water pollution around 500 ha, yields dropped to 30-40%. In addition, some places have to give up polluted land, fallow land area reach up to tens of hectares, scattered in the provinces of Bac Ninh, Hai Phong, Nghe An, Dong Nai ... With an estimate of 70 tons/ha and selling price of 600,000 VND kg, the amount of damage caused by water pollution is quite large. With an 8% productivity losses, the damage was approximately 6.72 million/ha/year. In highly polluted areas that have to be abandoned, the damage about 84 million/ha/year for 2-rice-crop structure (Nam Dinh and Bac Ninh) and 126 million/ha/year for 3-crop structure as in Kien Giang and Dong Nai.

At the same time, the estimated loss of 1 ha/year showed that at the commune level, Man Xa Commune, Yen Phong District, Bac Ninh Province (area Red River Delta) experience a severe yield damage of 14 tons/ha/year, equivalent to economic losses of about 3.9 billion/year. In Yen Phong district - Bac Ninh and Yen My - Hung Yen, due to huge affected area, the damage is about 12.6 billion/year. In Mekong Delta, specifically Linh Huynh, Linh Huynh Commune, Hon Dat District, Kien Giang Province, the damaged area has an area of ​​up to 180 ha, with losses of 80 -100%, the estimated value of approximately 22.7 billion/year in Vung Gam Fields, Phuoc An commune, Nhon Trach district, Dong Nai province damage level goess up to 6.3 billion/year.

Thus, the level of economic losses in agricultural production in some areas affected by sewage is quite large, which reduces the life quality of people, damages the local economy, at the same time significantly reduce the agricultural GDP of the country.

**Damages caused by water pollution to tourism**

Our country's tourism industry is almost completely dependent on the landscape and the cleanliness of the beach areas, surface waters (lakes, rivers, ...). For example, Hanoi attracted domestic and foreign tourists thanks to the system of lakes in Hanoi (the core area consists of six main districts and has more than 120 large and small ponds). Of all, West Lake and Hoan Kiem Lake are the world-famous lakes attached to landscapes of Hanoi. The beautiful beaches throughout more than three thousand kilometers along the coast from Quang Ninh, Hai Phong to Ca Mau attract tourists and bring huge revenues to the country's GDP. In addition to the beachs, the river also provides diverse travel services (Han River, Huong River, ...). The catering services in the tourism industry including hotels and restaurants, fishing, production of food, transportation, commercial business, ... created a lot of jobs and incomes for the people of these regions. Obviously, the surface water is the foundation for smokeless industry. Pollution of surface waters, whether it is large or small, can kill tourism and thus all corresponding services.

No calculations have given specific figures on the damage caused by water pollution to tourism, but it can be seen that water pollution but will cause immense damage to the tourism as well as following fields dependent on this sector.

# IMPACTS AND DAMAGES CAUSED BY WATER POLLUTION TO HUMAN HEALTH

Influence of surface water pollution on public health may be through two ways: by eating, drinking contaminated water or vegetables, seafood grown in contaminated water and exposing to environmentally polluted water in the process of living and labor.



**Diagram 3: Pathway of water pollution impacts on public health**

**Risks of infectious diseases caused by microorganism-contaminated surface water in Vietnam**

Microbial pollution in water: harmful microorganisms in water such as bacteria, viruses and parasites originating from domestic waste of humans and animals can cause diseases such as cholera, dysentery, typhoid, gynecological infections, pinkeye, gastrointestinal disorders or poisoning food, poisoning drinking water, diseases related to worms .... In the aquatic environment, the microorganisms easily spread and make widespread epidemics. According to the scientific literature in the world, more than 300 kinds of diseases transmitted through water [12].

Currently in many parts of Vietnam, there are still many households using water from rivers, lakes and canals to serve the daily activities. According to Ministry of Health, the number is 20% (mainly in some rural areas and poor areas) [14]. The use of this water source for drinking and eating is a factor increasing the infectious diseases related to water and sanitation of local people when water source is contaminated.

In Vietnam, according to WHO and UNICEF in 2011, the number of deaths due to diseases related to water and sanitation is 14 531 cases/ year, accounting for 3% of the mortality rate in the country. According to this report, the number of years lost due to death and healthy life years lost (DALYs) due to diseases related to water and sanitation is 765 738, constituting 6% of the total disease burden of the country [13]. According to another report of the Department of Water Resources Management in 2010, 80% of cases of dysentery and diarrhea are due to polluted water sources, mainly in poor localities. There have been cases of deaths caused by dirty water use and pollution (mainly children) [11].

Moreover, in many parts of Vietnam, people are using very polluted water for agricultural activities. In particular, in some suburban areas of Hanoi (Gia Lam, Hoang Mai, Yen So), people still use water from Kim Nguu River and To Lich River for planting vegetables, raising fish, and growing rice [10]. The use of contaminated water resources in agriculture poses a high risk of infectious diseases for not only the direct employees but also for the consumers of aquaculture products. Several studies have shown that the incidence of diseases related to the gastrointestinal tract in riverside villages are usually higher than the communes unaffected by river water (Diagram1 and Diagram 2) [17, 26], and the incidence of gastrointestinal diseases in the group of people directly exposing to contaminated water is much higher compared with no exposure [14.20].

*Domestic toxic metal pollution* (lead, mercury, ...): Toxic metals in the water can accumulate in sediments, and it is very difficult to handle. Thus they could enter the food chain through fish, mollusks, ... and eventually will break the ecosystem. Toxic metal pollution often causes environmental disaster as it happened in Minamata Bay Japan (1956) and recently at a mine between Romania and Hungary (2001). Environmental disasters are associated with diseases such as cancer, birth defects, ... which may have consequences for many generations.

*Contamination of organic compounds in the water*: The synthesis of organic compounds includes pigments, plant protection products, growth stimulants, additives in the pharmaceutical products, and food. These substances often have high toxicity and biologically high durability, especially aromatic hydrocarbons pollute the environment and cause significant impacts on human health. This is the cause of chronic poisoning and diseases such as liver cancer, bladder cancer, lung cancer, gastrointestinal cancer, neurological diseases.

In Vietnam, no study has been conducted to evaluate the levels of toxic substances, heavy metals in agricultural products farmed in polluted waters, and no review of any evaluation of the risk of non-transmissible diseases, especially cancer in communities. However, with the current deterioration of surface water Vietnam, combined with the many places forced to use contaminated water sources for agriculture, it will lead to a high risk of exposure to hazardous substances in polluted water, leading to the potential impact on human health as stated above.

**Minamata: horrifying disease because water sources of mercury poisoning in Japan**

Right on time for its magical development (the end of 1960s – beginning of 1970s), Japan faced the horrors called Minamata disaster, disaster with methyl mercury poisoning from consumption of widespread mercury-contaminated seafood from Minamata Bay. The disease was discovered for the first time in Minamata of Kumamoto Prefecture in 1956 (becoming the first human disease due to exposure to plants, animals infected from the environment), and in 1968, Japanese government officially declared the disease caused by the company Chisso because of discharging mercury containing waste water into Minamata Bay, making it contaminated. According to Japanese scientists, Minamata disease is terrible, and can be compared with the nuclear disaster in Hiroshima, or Nagasaki.

Minamata disease left many horrific consequences depending on the severity of poisoning. Seriously ill patients experience often shrieking in pain, frequent seizures and paralysis. Some patients are blind, deaf or insane, and many who experience less tremble limbs, numbness, lose balance. Methyl mercury-infected women during pregnancy run the risk of cerebral palsy birth, babies with deafness, blindness, or too small head, or big, and slow growing mind.

***How many patients with this disease are there?***

According to Government of Japan, 12 890 people in total have been infected so far. However this is only statistical figures based on the government petition that has been formally recognized, the actual figure will be much higher because some died before the disease was officially discovered, many people die before they could get disease certification, and many people do not apply the certification for several reasons.

***Minamata burden caused by disasters***

Economic damage: The total amount of compensation to the victims affected by Minamata and costs to clean up Minamata Bay reach 308.5 billion yen (equivalent to US $2.829 billion). Of all, 260 billion yen is the amount that Chisso paid as compensation to the victims of disease, 48.5 billion yen as the cost Kumamoto Prefecture spent to dredge the Minamata Bay.

Social burden: as analyzed above, the number of people affected by Minamata disease was even more than 12 890 people, and most of them have no cognitive ability and difficulty of travel again, and rely entirely on the parents. No solution has completely cured Minamata disease. Most patients have to go to the hospital daily for treatment and recovery. Currently, when patients become older, the number of members must be located in hospital or in need of assistance at home also increase. In an aging society in Japan, the burden of these patients is very significant.

\* During a long period in 1932-1958, Chisso company discharged into Minamata Bay in Kumamoto province a tremendous amount of sewage. Until the company stopped production in 1968, the amount discharged into Minamata Bay has turned this Bay changed completely like a dead gulf. According to recent studies, the amount of mercury has not been processed in the period that Chisso Minamata Bay discharged at that time in each period is 0.6 to 6 tons. And the level of danger has been studied so far. [15,18,19,33]

**The cost to fix the health impact of water pollution**

Vietnam does not have a comprehensive study assessing the economic burden caused by the treatment of diseases caused surface water pollution, but according to statistics by the Ministry of Health, in 2006 - 2010, Vietnam had about 6 million cases of group-related diseases water pollution (cholera, dysentery, typhoid, malaria), and the cost of treatment for 6 million cases reached the number of 400 billion. Thus the average cost per year for treatment of these diseases is 100 billion.

In addition, diseases related to environmental pollution also affects family members through indirect cost due to school holidays, off work due to sick relatives. Most people who have days off for sick treatment or have sick relatives, shall have 20% reduce in income and health decline approximately 20% compared to before the illness. Furthermore, the influence of psychological instability makes it difficult to concentrate on work and education, eventually leading to low efficiency, even in multiple occupations, the loss in peace of mind will cause labor serious consequences on the economy and life. [20]

# STORIES OF THE WATER POLLUTION IN VIETNAM

**Pollution story in Bung Cu-Binh Duong stream**

Bung Cu stream derives from Binh Chuan ward, Thuan An town and flows through Thai Hoa commune and Thach Phuoc town, Tan Uyen district to the region of Ba Kien bridge before pouring into the Dong Nai River. The entire length of the stream is 4.35 kilometers. The stream from beginning to an end looks like an ice cream cone as the narrow tip gradually expands. In the upstream area, water goes through the stream about 1 meter wide. the width of the stream increase gradually, the segment running through Binh Chuan is 2 meters wide, the part through to Thai Hoa is 4 meters wide and when it arrives Dong Nai River, the width is now up to 30 meters.

Historical root of Bung Cu stream is original. According to legend, more than 200 years ago, Pham Van Thuan, from Tan Khanh – Ba Tra region, while doing farming work, met a man who said: Formerly a Cu tu woke up, which formed the small stream with cool and clear water. Thanks to it, the villagers of Phuoc Loc (now Binh Phuoc Ward) got drinking water and irrigation water.

Hearing that, Mr. Thuan and local people built a temple to worship this stream, called Mr. Cu Fane. Later, General Nguyen Van Thu, from Tan Khanh rebuilt the temple wider to worship ancestors and rename Bung Cu Temple (Mr. Cu Fane is located on the campus of Bung Cu Temple). In 1858, King Tu Duc ordained Bung Cu Temple and the stamp is not still stored.

Bung Cu stream water was drinkable previously. When people went working at field, if they are hot, they can go down to bath in the stream. They can catch and cook fish and crab and food is ready to eat. It is said that decades ago clear Bung Cu stream was a place for dating couples, but it is now black and smelly, garbage covers the stream. The water level is only to a half calf high, yet the water is so dirty that no one dared to go through. Thanks to Bung Cu stream, the place was formerly a rich and prosperous agricultural region. Now it is still named Bung Cu stream but instead of clear and transparent to the bottom, it is a dark and polluted stream with so much junk. (Source: The Communist Party of Vietnam Online Newspaper 2007).

It is estimated that every day this stream receives about 8.000 m3 waste water from more than 70 companies. Most of sewages are untreated and discharged directly into streams, causing serious organic pollution. Additionally, the situation even worsens due to the contribution of 1600 motel rooms with about 5,000 workers who have low environmental protection awareness and litter everywhere (Ô nhiễm môi trường ở Bình Dương: Khổ lắm, nói mãi tới bao giờ!?, literally “Environmental pollution in Binh Duong: Suffering too, talking until when !?” on News and Events page, Ministry of Natural Resources and Environment, September 2008).

In 2011, according to a survey by Department of Natural Resources and Environment Binh Duong Province, Bung Cu stream received waste water from more than 100 businesses and nearly 1,600 inns located in Tan Uyen district and Thuan An town with untreated sewage flow of about 15,000m3/day, polluting the Bung Cu stream seriously. Because ofreceiving untreated sewage, Bung Cu stream is in serious organic pollution, COD concentration exceeds standard 2-4 times concentration of NH4 exceeds standard 8-12 times, some places have signs heavy metals contamination. (Binh Duong took actions on pollution in Bung Cu stream, Pollution Control page, Vietnam Environment Administration website).

Water pollution in Bung Cu stream caused major impacts on farming activities of people. The fields or crops do not bring income farmers due to high incurring costs, including fuel costs due to pumping groundwater for irrigation and unstable price of crops. Currently farmers produce in moderation and hope to have the renovation project of Bung Cu stream done, riparian land will be cleared and farmers will be compensated.

In 2016, Coalition for Clean Water coordinating with People's Committee of Tan Phuoc Khanh ward plans to have specific actions to address pollution in Bung Cu stream through activities such as dredging waste, off the flow, media and raising public awareness, building garbage collection plan. Specifically, on 24.04.2016, the Union and the People's Committee of Tan Phuoc Khanh Ward held successful operations of cleaning the beginning of Bung Cu stream with the participation of government and local organizations, students of Binh Duong university, and especially with the enthusiastic participation of two army units stationing there. Activities not only directly improved water quality of Bung Cu stream but also raised awareness for local communities and influenced the authority of Tan Uyen town on accelerating the plan to protect the environment in the region.

Raising awareness for the community builds consensus and determination in protecting surface water sources in Bung Cu was a big success of LMNS in the operation of controlling water pollution in local scale, but more importantly there is still in need of a water pollution control law separating from specific policies to ensure effective implementation in order to save small streams and canals crisscrossing the country, bring the sacred polluted water back as the source of clean water, which can serve and inspire all people.

**Pollution story in Bó Cá-Sơn La stream**

Bo Ca stream basin is located on the 3 provincial administrative units of Son La Province including Thuan Chau district, Muong La district, Son La city. Downstream areas of t Bo Ca stream basin is Tat Tong cave, which is located right next to Bo village, Chieng An Ward, Son La city. This is a natural cave. Previously, flowing water in the cave is very abundant, so local people can use for domestic activities, and agricultural production. Currently, part of the water taken from Tat Tong cave is used by Son La water supply plants to provide clean water for 11,000 households in Son La city with a capacity of 12,500 m3/day and a part for production agriculture.

Over the years, coffee processing facilities in the region of Chieng Co commune, Chieng Den (Son La city), and the Dong Hung village (Muoi Noi commune, Thuan Chau district) have been discharging untreated waste water directly into the environment, which pollutes the water supply for Son La Water Enterprise. From 2012 to 2014, when the coffee harvest occurred from October to December each year, the city water plant stopped production from once to twice, each time from 12 to 24 hours. The longest time is 36 hours, causing significant impact to the daily life of people in the city of Son La. In particular, in October 2015, factories had to shut down four times due to polluted water sources.

The coffee semi-processing in Son La is mainly by wet method, so the amount of waste water in the production process is quite large. Currently, all households and coffee businesses here have no waste treatment processes implemented. Currently, a part of coffee husk waste was buried in the pits to make fertilizer. The only single method to treat coffee waste water is digging lodgment, but after a while, this waste water will go into ground water or will overflow into the plant's water supply during rain. In addition, the use of pesticides, herbicides and chemical fertilizers are common. In particular, the use of agricultural chemicals on slopes makes chemical residues quickly enter the streams within the basin.

Under these circumstances, Son La province has made initial actions to prevent and control pollution sources through the sanctions to stop business from polluting. However, the situation of water pollution from coffee processing remains undiminished, because besides firms, there is a large volume of waste water coming from the households. Therefore, the implementation of a legal framework for penalties are very tough. furthermore, due to low economic conditions, limited educational level, the application of waste and sewage treatment technologies is also facing many difficulties.

In 2014 and 2015, the Coalition for Clean Water and Tay Bac University have preliminary study about the current situation of contamination and the implementation of community participation model of water pollution monitoring to provide information to the local environmental management authority as well as raise awareness of people. In 2016, the Union planned to implement more specific activities to gradually tackle water pollution from coffee semi-processing in Son La through research support and adoption of treatment technology of sewage from preliminary coffee processing on household scale, support and technical advice for businesses, and local governments along with stakeholders and develop a plan to control water pollution in the locality. Pollution problems of water supply for the city of Son La can only be resolved when both the government and enterprises and people working together.

**Pollution story in canal 4 commune – Bac Ninh**

With a total length of 3,100 m, 4-commune canal runs through the territory of Khac Niem ward (Bac Ninh city) and the communes: Tan Chi, Lac Ve, Lien Bao (Tien Du district) and then pours into the Tao Khe River. 4-commune canal is responsible for irrigation for farms in the region. However, this canal now receives untreated or poorly treated waste water from noodle production facilities in Tien Trong and Tien Ngoai village, Khac Niem commune, waste water from small sites and medium farms in Lac Ve and Tan Chi village, sewage from livestock enterprises (including geese breed enterprises, Lac Ve pig breed one member Ltd. Company, DABACO Co.Ltd Food Processing), as well as the drainage channel for domestic waste water from households living around the area. The survey results of the Center for Environment and Community Research (CECR) in September 2015 showed that there are 40 discharging points along the 3-km length of the canal. 4-commune canal is currently one of the points that discharge the most polluted waste water into Tao Khe River.

***Influence on agriculture and fishery***

Agriculture is still the main production sectors of people around 4-commune canal areas but due to contaminated irrigation water, the crop is slowed down. If water is still being use in the fields, rice will be affected as root rot, many pests, rice thrives but gives poor productivity. This phenomenon has taken place since 2008, severely affected fields are in Van Trung village, Chi Dong - Tan Chi commune, Lac Ve commune. If the previous yield (before 2008) is 0.2 to 0.25 tons/acres, it is only 0.1 to 0.13 tons/acre now. In order to limit the impact of water pollution on agricultural production, the villagers have to dig a different canal, separating from the old canal system to capture rainwater to serve rice production, but this is only is a temporary solution.

Contaminated water also reduces the productivity of aquaculture in the area bordering 4-commune canal. There was time that phenomenon of mass fish death appeared, causing a lot of economic losses for households here. The fishing on 4-commune canal was also wiped out.

***Influencing on water supply***

Clean water plant began supplying water to villagers Van Trung - Tan Chi since 2011. In the beginning, 100 households in the village connected to the system to use the water, but so far only about 50% of households use. The reason is that the water system of the plant is located on the 4-commune canal which is heavily polluted, so people were worried that the groundwater that system takes from can also be contaminated. In addition, pumping pipes of the plant broke twice, causing more anxiety about contaminated water from 4-commune canal going into the pipes.

***Influencing on life and health***

Because the system of field canals is close to residential areas, each time water is used for agriculture and polluted water stinks, affecting daily life of the people living around it. Water is so polluted that it can cause itching just by touching skin. As report by clinincs in Tan Chi commune, more and more people comes to the clinic to ask for medicine during the transplant in comparison to other periods of the year. This phenomenon only started occurring in recent two years.

To completely solve water pollution in 4-commune canal, Department of Natural Resources and Environment of Bac Ninh province has plans to renovate the waste water treatment system for the noodle village Khac Niem, and urge enterprises of Group DABACO quickly build and operate the waste water treatment system, stop the discharge of untreated waste water into the environment. With the collaboration of the Center for Environmental Research and Community (CECR) and the Coalition for Clean Water in technical support and mobilizing role of community supervision, hoping 4-commune canal water quality will be restored in the near future.

**1. The story of water pollution in Dock Tho Quang-Da Nang**

Tho Quang - Da Nang Dock is the place where boats anchor when big storms come. This area is built as approved plans by People's Committee of Da Nang City and put into use in 2004 with 58 hectares of water surface and 25 hectares of ground. This ensures that around 1,000 fishing boats can anchor and avoid storm. Over almost 12 years, the dock has fallen into overload state. During rainy days, Tho Quang Dock is full of fishing vessels. Due to that, water pollution increased significantly.

It can be said that this area receives a lot of different sources of waste including domestic waste water, industrial waste water from seafood processing plants, waste water and municipal waste from the fish market area, waste and sewage from ships, and waste water from the fish cages. Much of this waste sources are not collected and handled for a long time, leading to sediment accumulation, and stench from decomposition. Odor at the dock and fishing port Tho Quang not only sticks clothes and meals of households living along the east side of Han River, but also affects tourists visiting Da Nang. This is not a beautiful image for the tourists coming to the city.

*Water pollution caused by management mechanism or by people’s awareness?*

One of the causes leading to pollution in the dock area is the waste of the boats anchoring at the fishing port and going out to the jetty. Fishing Port is the largest port in central Vietnam, with seafood wholesale markets at the national level, so it attracts many ships from other provinces. If the residence time of these boats is long, the amount of waste also increases.

The amount of discharged waste is mainly municipal waste from fishermen. Fishermen that have fishing boats anchoring at Tho Quang Dock admitted that they drop down garbage floating on the water. When asked why they did not on shore, some fishermen said that they were accustomed to drop garbage down the river. It is hard to blame fishermen for arbitrarily littering, because everyone understands that to change the habits of fishermen who lived temporarily on "dog house" along Han River or empty houses along the coast is not easy. (Source: Dai Doan Ket newspaper, January 2016). In addition, waste comes from seafood preservation process, ice surplus; washing boats, washing tools and instruments, such as balls, boxes, barrels, fishing nets. Waste, sewage on board, the boat was discharged directly into surface waters around the dock.

Although direct management unit, which is Dock and Fishing port Tho Quang Management Board strived to collect, raise awareness and remind but due to custom and habits of fishermen, littering is still quite common

*There are many solutions, but are they really effective?*

Facing this situation, People's Committee of Da Nang has agreed Environmental Science and Technology Quoc Viet Ltd. Company (Quoc Viet Company for short) to invest, construct and operate focused sewage treatment plant of Fisheries Service Industrial Zone Da Nang in the form of BO, a scale of 7.000m2, processing power of 5,000m3/day (in stage 1 treatment of 2.500m3/day). However, building the treatment plant is not enough if it is done well because awareness of local people and habits of disposing indiscriminate waste do not change.

Thus, in 2016, the Coalition for Clean Water along with Department of Environment in Da Nang city plans to found supervision board to control pollution in the dock area with the aim to raise awareness, to change the behavior of communities living in the area and community on the boats anchoring the dock. Specifically, the board including members of the dock management unit, the fish market management board, ... will check periodically and detect any pollution/discharge operations within the dock, and then report to management to find appropriate solutions. At the same time, direct media and education awareness for owners whose boats are anchoring at the dock make them more aware and gradually change littering habits, make changes gradually learning habits litter discharge. Through practical activities, the Coalition for Clean Water will have recommendations suitable with reality to the city authority in the implementation of plans to control waste water pollution at the dock.

**Water pollution story of lakes in Hanoi**

Ponds and lakes are a typical eature, the face and the soul of the capital Hanoi. However, over the years, the system of lakes in the capital are under a lot of pressure on the environment. Lots of lakes are in heavy pollution and high risk of encroachment (due to not zoned or lack of embankment) such as Linh Quang Lake, small Kim Lien lake ... Many lakes are still receiving waste water from surrounding households (Ho Me lake, small Kim Lien lake, Linh Quang lake, Van Chuong lake ....), some lakes are still responsible for raising fish for economic purposes (Ao Phu, Nam Dong lake, Thien Quang lake, ...).

Only in early 2016, many lakes fall into serious pollution, affecting the life of people. Press and media have published a lot regarding this issue. For example, Ngoc Khanh Lake has recently been renovated, but already contaminated (dark black water and stench affect people living nearby). The most recent incident is on 8/6 with the mass fish death in Hoang Cau lake.

The lake protection is shown on many legal documents such as the Environmental Protection Law, Law on Water Resources, Biodiversity Protection Law and the bylaws such as Decision No. 11/2011/QĐ-UBND on March 2, 2011 on decentralization of state management in some socio-economic sectors on Hanoi area during the period 2011 - 2015. There is a whole system of institutions including laws, and each hierarchy of management will have a clear decentralized mandate. At People's Committee of municipal level, Departments work related to lake environmental management, Department of Agriculture and Rural Development manages aquaculture, Department of Construction works on water supply and drainage construction, Department of Transportation and Department of Architecture work on construction, water transportation and architecture, Department of Culture and Tourism takes care of cultural activities, tourism and sports. Department of Construction is the main agency working on the implementation of lake environmental improvement projects and Hanoi Drainage Company is responsible for management and maintaining the drainage system in Hanoi and waste water treatment, including management of 59 lakes. Also there are historical lakes managed by monument agency. Different departments will support People’s Committee of Hanoi in making different decisions for lakes.

It can be seen that the current system of regulation and the relevant agencies involved in protecting lakes in Hanoi is quite full. However, the lake water quality has not been improved? In addition to the normative documents, from 2009 until now, Hanoi has more interest in the rehabilitation and treatment of lake water quality. There are some concerning questions that it is time to change the function of the lakes in Hanoi to the environmental landscape and storm water conditioning. Currently lakes in Hanoi have both functions as part of drainage system and fish raising area, so despites the investment of the city, the lakes are still polluted. Decision No. 2249/QĐ-UBND, issued on May 18, 2011 on regulations of management of lake water quality after contamination treatment prohibited fish in the treated lakes. However, raising fish in many treated lakes such as Nam Dong lake, Hai Ba Trung Lake, Den Lu lake are still going on. Therefore, another question is whether normative documents have good performance? Is the administrative management system outlined above can ensure accountability of the stakeholders with regards to the health of the lake?

**Conclusion**

Environmental disasters leading to ​​massive fish death in Central Sea, fish death in Buoi River at the same time around April-May, 2016 is an alarm about surface water pollution in our country. Protection of fresh surface water including rivers, lakes, coastal waters to ensure the growth of fish, shrimp, crabs, and mollusks, aquatic creatures and all human activities related to water must become the top priority in environmental protection work. There is clean water, there will be all: seafood and seafood products, tourism services and livelihood activities associated with travel, health and welfare of the water-related services. Life only exists when there is clean water.

Surface water area are seriously polluted by contaminants in untreated waste water discharged directly into water sources. Pollution control is to prevent the pollutants from going into surface waters. Water pollution control depends on process technology, strict scientific methods, and requires accurate information, transparency, large investment as well as time.

References part 1 of “Water pollution: Current affairs, effects on health and economy” provides basic information about surface waters, water pollution sources and damages caused by water pollution. The next document will focus on analyzing the policies of the current water pollution control, some lessons of overseas water pollution control used to formulate policies and legislation to prevent and control water pollution, gradually restore the water ecosystems of our country.

**References**

**VIETNAMESE**

1. Annalee Yassi, Tord kjellstom, et al. Environmental Health (Environmental Health course, Hanoi University of Public Health translated). Oxford University Press
2. Lê Hoàng Anh, Mạc Thị Anh Trà, Center for Environmental Portal. Current state of continental surface water environment – Challenges in management work. *Environment Journal 2014*, vol 1: 14-17
3. Nguyễn Hoàng Ánh, Pollution Control Agency – Vietnam Environment Administration. Report on proposal of building Water Pollution Control Law. Hanoi, 2015
4. Lê Thị Minh Ánh, Department of Policy and Legislation - Vietnam Environment Administration. Thematic Report - Review of shortcomings and gaps in the legal system at current legal documents related to the Water Pollution Control of Ministry of Natural Resources and Environment. Hanoi, 2015
5. Central Propaganda Department. 100 questions – answers about seas and islands for Vietnamese youth. Hanoi, 2013, Information and Communication Publishing House.
6. Hoàng Văn Bảy, Department of Water Resources Management. The legal system of water resources protection and the problems to strengthen water pollution control. *Report at workshop of policy legislation on water pollution control*; 8/5/2015; Hanoi, Vietnam
7. Management Board of relics and scenic spots in Dong Nai. [cited on 1/6/2016] Retrieved from: URL:

<http://disandongnai.com/home/index.php?mod=mice&func=view&id=1076&cid=687>

1. Ministry of Natural Resources and Environment. Overview of surface water in Vietnam. *Report at National Environment Conference 2012 – Surface water environment*. Hanoi, 2012: 3-22
2. Ministry of Natural Resources and Environment. Nguồn gây ô nhiễm môi trường nước mặt. *Report at National Environment Conference 2012 – Surface water environment*. Hanoi, 2012: 25-40
3. Ministry of Natural Resources and Environment. Diễn biến chất lượng nước mặt. *Report at National Environment Conference 2012 – Surface water environment*. Hanoi, 2012: 43-63
4. Ministry of Natural Resources and Environment. Influences of surface water pollution. *Report at National Environment Conference 2012 – Surface water environment*. Hanoi, 2012: 43-63
5. Ministry of Natural Resources and Environment. Report at National Environment Conference 2014 – Village Environment. Hanoi, 2014
6. Health Environment Management Agency, WHO Vietnam, UNICEF Việt Nam. Water, sanitation and development: the aspects of health, society and economics. *Report Review* *of water supply and sanitation in Vietnam.* 2012: 18 – 28
7. General Department of Preventative Medicine, UNICEF Việt Nam. Summary of environmental sanitation and personal hygiene in rural Vietnam. Hanoi, 2007: 12
8. Voice of Vietnam. Deadly disaster in waters Minamata (Japan) due to poisoning. [Internet]. 25/4/2016 [cited on ngày 1/6/2016] Retrieved from: URL: <http://vov.vn/the-gioi/ho-so/tham-hoa-chet-nguoi-o-vung-bien-minamata-nhat-ban-do-bi-dau-doc-503894.vov>
9. Nguyễn Thị Thúy Hà, Trung tâm Dữ liệu và Hỗ trợ ứng phó sự cố hóa chất CECHEDAR, Vietnam Chemicals Agency – Ministry of Industry and Trade.Thematic Report - Review of shortcomings and gaps in the legal system at current legal documents related to the Water Pollution Control of Ministry of Industry and Trade. *Report at workshop of policy legislation on water pollution control*; 8/5/2015; Hà Nội, Việt Nam
10. Nguyễn Công Khương, Trần Hữu Bích, cs. Assessment of the diarrhea risk caused by microorganisms in exposure of feces and waste water use in agriculture in Ha Nam Province. Public Health Journal 2011, vol 22 (22): 14-20
11. Youth and Student Association of Vietnam in Japan. Minamata disease that cannot be forgotten (part 1). [Internet]. 30/5/2004 [cited on 1/6/2016] Retrieved from: URL: <http://www.vysajp.org/news/b%E1%BB%87nh-minamata-di%E1%BB%81u-ng%C6%B0%E1%BB%9Di-nh%E1%BA%ADt-khong-th%E1%BB%83-nao-quen/>
12. Youth and Student Association of Vietnam in Japan. Minamata disease that cannot be forgotten (part 2). [Internet]. 2/6/2004 [cited on ngày 1/6/2016] Retrieved from: URL: <http://www.vysajp.org/news/can-b%E1%BB%87nh-minamata-di%E1%BB%81u-ng%C6%B0oi-nh%E1%BA%ADt-khong-th%E1%BB%83-nao-quen-ph%E1%BA%A7n-2/>
13. Trần Khánh Long, Public Health University. Research overview of water pollution influence on health and economics. Hanoi. 2014
14. Coalition for Clean Water. Management, control of environmental pollution in inter-regional countries - some recommendations. Hanoi, 2014
15. Vũ Dương Quỳnh, Institute for Agricultural Environment. Studies assessing damages caused by water pollution to agriculture. Hanoi, 2015
16. Trần Đức Thạnh, Nguyễn Hữu Cử, Đỗ Công Trung, Đặng Ngọc Thanh – Vietnam Academy of Science and Technology. Coastal bays in Vietnam and the potential uses. Hanoi, 2009, Natural Science and Technology Publishing House.
17. Hoàng Văn Thắng, Lê Diên Trực, CRES, Hanoi National University. The classification system of wetlands in Vietnam. Environmental Protection Agency, Program of biodiversity conservation wetlands in Mekong River
18. Phạm Anh Tuấn, Directorate of Fisheries. Studies assessing damages caused by water pollution to aquaculture. Hanoi, 2015
19. Đỗ Thùy Trang, Bùi Thị Thu Hiền, cs. Risks affecting health from the use of waste water in agriculture in some peri-urban areas in Vietnam. Public Health Journal 2011, 22(22): 21-28
20. Center for Environment and Community Research. Report of lakes in Hanoi 2015. Hanoi: Women Publishing House, 2015
21. Tạp chí điện tử Quốc phòng toàn dân. [Internet]. 25/2/2013 [trích dẫn ngày 1/6/2016] Lấy từ: URL: <http://tapchiqptd.vn/vi/bien-dao-viet-nam/vung-noi-thuy-theo-luat-bien-viet-nam/3620.html>
22. World Bank, Australian Aid. Activity reports of evaluation on management of urban wastewater Vietnam. Hanoi, 2013.
23. VnExpress. Fisheries Association suggested early disclosure of massive fish death. [Internet]. 27/5/2016  [cited on 27/5/2016 ] Retrieved from: URL: <http://vnexpress.net/tin-tuc/thoi-su/hoi-nghe-ca-de-nghi-som-cong-bo-thong-tin-ca-chet-hang-loat-3409820.html>
24. Trần Thanh Xuân. Network of rivers and water resources Vietnam: changes and challenges. Hà Nội, 2015, Science and Technology Publishing House: p.249 -250
25. Center for Environment and Community Research. Statistics on environmental protection on Vietnam Environment Administration website. Hanoi, 2013

**ENGLISH**

1. Minamata Disease Municipal Museum. Ten things to know about minamata disease. [Internet]. 1999 [cited on 20/4/2016] Retrieved from URL:

[www.soshisha.org/english/10tishiki\_e/10chisiki\_3\_e.pdf](http://www.soshisha.org/english/10tishiki_e/10chisiki_3_e.pdf)