Chapter II.

THE ALARMING POLLUTION IN THE THREE RIVER BASINS OF CAU, NHUE - DAY AND DONG NAI

2.1. PREAMBLE

Water quality standards are the limits, which are used for assessing physical, chemical and biological characteristics and other sensitive features (colors, smells) of water. Assessing water quality should be based on the utilisation of, and demand for, the water source.

The set of water quality standards is used for assessing the water for different utilisations, such as water for domestic use, water for aquaculture, etc. In this Report, the surface water standards of TCVN-1995 are used for assessing the water quality of the 3 river basins. These standards define the limits of water parameters and permitted concentration of pollutants existing in surface water and are applicable for assessing the levels of pollution of a water source. Of which:

- TCVN-1995 (A): is applicable for surface water for domestic usage (after being properly treated in accordance with regulations).

- TCVN-1995 (B): is applicable for surface water of other usage. Water for agriculture and aquaculture is specifically regulated under other regulations.

Surface water sources of river basins are affected by both natural factors and socio-economic development activities occurring throughout the basin.

This Chapter focuses on analyzing river sections which are polluted or have signs of pollution in the three river basins. The analysis is based on monitored data and reports of respective local authorities and related agencies. To date monitoring programs of water quality (including river bed sludge) have not been comprehensive and complete due to a number of reasons. Therefore, the assessment of the water pollution does not yet cover all environmental components. This appears to be one of the weaknesses of water quality management and supervision that the related local authorities should overcome in the future.

2.2. CAU RIVER BASIN

2.2.1. The current state of the pollution

The surface water at the mid-stream and down-stream areas of Cau River is locally polluted by some organic pollutants, suspended solids (SS) and oil waste. In some sections, the pollution has become serious.

Cau River section flowing through Bac Kan province is polluted at some places

According to the monitored data, at Pha and Thac Rieng bridges (Bac Kan), the parameters of BOD5 and SS have exceeded the TCVN-1995 (type A) (Figure 2.1)

![Figure 2.1. The BOD5 content in Cau River section flowing through Bac Kan province](Source: VEPA)
Cau River section flowing through Thai Nguyen province is seriously polluted, especially at the part flowing through Thai Nguyen city.

Cau River section before entering Thai Nguyen city shows the first signs of pollution. This is due to industrial, mining and agricultural activities along the river and its two branches, e.g. Nghinh Tuong and Du Rivers (Nghinh Tuong River is affected by gold mining activities; the down stream of Du River receives waste water from Phan Me coal mine).

In Cau River section flowing through Thai Nguyen city the water is seriously polluted, containing many organic compounds and oil compounds.

At Tan Long ward, the water is very turbid with black color and bad smell. At the section flowing through Thai Nguyen Metallurgy industrial zone, the SS, BOD₅, COD parameters exceed the TCVN 5942-1995 (type A) by two-three times (Figure 2.2); the river water has a distinct oily smell (Figure 2.3).

In Phuong Hoang stream (a small stream flowing through Tan Long ward, Thai Nguyen city), the water is severely polluted by organic pollutants. This is due to the untreated waste water with very high content of nitrogenous compounds from a paper mill directly discharging into the stream. The typical parameters indicating the pollution are BOD₅, COD, etc. (Figure 2.4).

Cong River is the second largest river in the basin. It flows through Thai Nguyen provincial area and merges with Cau River at Da Phuc. The river water shows initial signs of organic and oil pollution. Agricultural chemical residues have also been found at some points. Figure 2.5 shows the average values of oil content in the whole river section in 2004 and 2005. This river section is impacted by tourism activities on Nui Coc Lake, sand exploitation boats on the river, and waste water from mining activities and from Cong River Industrial Zone.
The water quality at some points of Cau River section from Vat bridge to Pha Lai has become worse than permitted standards and polluted by organic substances.

The water quality in the downstream area (the section passing through Bac Giang and Bac Ninh) of Cau River has been relatively severely polluted by organic substances (Figure 2.6). The final section of Cau River, at Pha Lai, is impacted by water transportation. Moreover, the downstream section of the basin receives water from Ca Lo River in Bac Giang and Ngu Huyen Khe River in Bac Ninh, while Ngu Huyen Khe River is already seriously polluted. This contributes to deteriorating water pollution in the basin. Oil scum is visible on the river water surface.

Ca Lo River flows through many industrial zones and clusters and urban areas of Vinh Phuc province and a part of Hanoi (Soc Son district, Dong Anh). Signs of organic pollution can be seen in the water. This is caused by waste water from domestic, urban and tourism activities and oil pollutants from industrial waste. The organic and nutritious contents exceed permitted standards type A. Oil pollution has been clearly demonstrated at Lo Cang bridge, Binh Xuyen.

Ngu Huyen Khe River is one of the most typically severely polluted rivers in Cau river basin. The pollution is due to economic activities of production establishments, especially from craft villages lying along the river from Dong Anh, Ha Noi to Van An and sewage of Bac Ninh (Ngu Huyen Khe River flows through Bac Ninh town and Tu Son, Yen Phong districts of Bac Ninh province). Along the river banks villages exist, focusing on food processing, animal husbandry, paper recycling, scrap recycling, metallurgy, etc. Most of the waste water from these villages is directly discharged into the river. The river water is organically polluted, the content of nutritious substances being higher than permitted standards TCVN 5942-1995 type A by tens times.
2.2.2. Causes of the pollution

Many polluting waste water sources are discharging to Cau basin. This section will discuss the source of pollution: including industrial activities, craft villages, domestic and medical activities according to their seriousness from low to high levels.

The socio-economic development activities in the basin have enormously impacted on the water quality. The economic structure of the river basin varies among provinces depending on whether they are located in mountainous, midland or plains areas. In Bac Kan, Bac Giang provinces and other solely agricultural areas on Cau river basin, the main sources of environmental pollution are domestic waste water and agricultural production activities. On the other hand, in districts lying along Cau River in Thai Nguyen, Bac Ninh, and Bac Giang. At the moment, in Thai Nguyen there are 27 industrial zones - comprising the highest number of industrial zones in six provinces in the river basin - of which 12 industrial zones have come into operation.

With regard to the total discharging volume, the waste water from the mining industry and mineral processing comprises the highest portion - 55%, following are the metallurgy industry - 29%, paper industry - 7% and agricultural and food processing - 4%.

Industrial waste water

According to statistical data of 2004, there are two thousand industrial enterprises active in the whole Cau river basin, of which the greatest part, comprising 28% of the enterprises is in Bac Giang, followed by Hai Duong with 23% and Bac Ninh 22%.

The main production sectors in Cau river basin are metallurgy, food processing, forestry goods processing, construction material production and transportation vehicle production. Industrial zones and large plants are located mainly in Thai Nguyen and Hai Duong, Bac Ninh and Bac Giang. At the moment, in Thai Nguyen there are 27 industrial zones - comprising the highest number of industrial zones in six provinces in the river basin - of which 12 industrial zones have come into operation.

With regard to the total discharging volume, the waste water from the mining industry and mineral processing comprises the highest portion - 55%, following are the metallurgy industry - 29%, paper industry - 7% and agricultural and food processing - 4%.
Table 2.1 shows the statistical data of waste water volume from some mineral mines located in Thai Nguyen. Data reveals that the waste water volume is tending to increase in recent years.

Metallurgy, steel, machinery manufacturing industries are located mostly in Thai Nguyen, with a total waste water volume of around 16,000 m³/day of which, the waste water from Thai Nguyen Metallurgy Industrial Zone has the most serious impact on water quality. Waste water from the Industrial Zone flows through two canals and flows into Cau River with an average volume estimated at 1.3 billion cubic meters per year. Steel production activities generate many toxic pollutants such as oil, phenol and cyanide. Currently the Industrial Zone has been equipped with waste water treatment systems with a view to reducing the pollution levels. The second largest industrial zone in Thai Nguyen is Song Cong Industrial Zone, which is located in Song Cong town. The Industrial Zone comprises mechanical engineering plants and motive machinery plants. This Industrial Zone came into operation in 2001 but no central waste water treatment system has been installed. In most plants in the Industrial Zone no waste water treatment systems have been installed either; primary sludge treatment systems are in place in some plants to carry out primary treatment only. Waste water from this industrial zone contains much oil and heavy metals as a typical characteristic of the mechanical engineering industry.

Paper production: this is a considerable polluting source to the basin with a total waste water volume of about 3,500 m³/day, of which, waste water from Hoang Van Thu Paper Mill (Thai Nguyen) has the most serious impact on water quality. Waste water from this mill contains inorganic pollutants, suspended fibers; the water has black color with high alkaline concentration and bad smell. In 2005, the company changed its production technology and in 2006 the company invested in a waste water treatment system in order to reduce the pollution. Next to Hoang Van Thu Paper mill, another paper mill producing paper for export also directly discharges its waste water to Phuong Hoang stream, Thai Nguyen.

Food processing: food production and processing establishments in provinces lying in Cau river basin generate about 2,000 m³/ day. The waste water contains organic compounds, glucose, lipid, bacteria and coliforms and is discharged directly to sewage systems, trenches and rivers without treatment making the surface water smell very badly.

Beside the above mentioned pollution sources, other plants, factories and production establishments of other sectors also discharge waste water to Cau river basin. Those include pharmaceutical pro-
duction establishments, garment factories, construction material production plants, packing material plants, automobile assembling factories, etc. The establishments located in the industrial zones and clusters of Vinh Phuc discharge their waste water to Ca Lo River without treatment or with only primary treatment; waste water from industrial clusters and production factories of Bac Giang province (such as Dinh Tran Industrial Zone, Song Khe - Noi Hoang Industrial Cluster, Ha Bac fertilizer and chemical factory, etc.) is discharged to surrounding water bodies after just primary treatment in the form of mechanical settlement; some large-scale factories like Dap Cau Glass Factory, Bac Son Tobacco Factory (Bac Ninh province) discharge their waste water to Ngu Huyen Khe River.

**Waste water from craft villages**

There are more than 200 craft villages specializing in paper production, alcohol distillation, metal plating, scrap recycling and pottery manufacturing. Most of the craft villages are centered in Bac Ninh province. The rest are scattered in Thai Nguyen, Vinh Phuc and Bac Giang provinces. Craft villages are characterized by a high volume of waste water, high level of pollution, no or insufficient treatment in place and waste water directly discharged to surface water sources.

Bac Ninh has the highest number of craft villages (more than 60 villages, comprising 31%). Most of the craft villages of Bac Ninh and Bac Giang are located along river banks therefore they have great impacts on the surface water of the basin.

Traditional craft villages of Bac Ninh province are diverse in production sectors.

<table>
<thead>
<tr>
<th>Villages</th>
<th>No of production est/ households</th>
<th>Waste water volume m³/day</th>
<th>BOD content kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phong Khe paper production village</td>
<td>64</td>
<td>3500</td>
<td>1.000-1.500</td>
</tr>
<tr>
<td>Phu Lam paper production village</td>
<td></td>
<td>2.000 - 2.500</td>
<td>260-330</td>
</tr>
<tr>
<td>Da Hoi steel and iron production village</td>
<td>450</td>
<td>15.000</td>
<td>600-675</td>
</tr>
<tr>
<td>Van Mon aluminium and lead casting village</td>
<td>80 - 120</td>
<td>500-1.000</td>
<td>5-25</td>
</tr>
</tbody>
</table>

Source: Bac Ninh DONRE, 2006

**Box 2.1. The current state of waste water in some craft villages in Bac Ninh province**

Phong Khe and Phu Lam paper recycling villages produce 18 - 20 thousands of paper a year and generate 5,500 - 6,000 m³ of waste water a day. The waste water from paper production contains hazardous chemicals such as alkali, detergents, alum, resin and artificial coloring agents. The BOD₅ content is 130 mg/l which is 4.3 times higher than permitted standards; the COD content is 617 mg/l, which is 6 times higher than the permitted standards.

Da Hoi steel production village produces about 500 - 700 tons of steel a day and generates 15,000 m³ of waste water a day. The waste water contains acid or alkali, oil, iron rust, the concentration of which exceeds permitted standards: the color level is 3.1 times, Fe is 3.3 times, Cr (VI) is 8.6 times and CN is two times higher than permitted standards.

Food processing households in Tam Da commune, Yen Phong district produce 1.2 - 1.3 millions of liters of alcohol a year. The waste water from the production process contains many organic substances and is discharged to Ngu Huyen Khe River without treatment.

Source: Report of the State-level scientific study - "The Environment of Cau river basin, 2003"
Most of them are located along Ngu Huyen Khe River. Most of the production establishments in craft villages are using outdated equipment, production activities are mostly at household scale and investment in waste water treatment is very limited. Most of the waste water from the craft villages is directly discharged to Ngu Huyen Khe River without treatment.

In Bac Giang province there are 25 craft villages, of which Van Ha is typical, specialising in alcohol distillation, rice sheet production and animal husbandry and Phuc Lam, specialising in slaughtering. The waste water from these two villages is directly discharged to the surrounding lakes and ponds, then flows into Cau river basin, causing organic pollution.

In Thai Nguyen province there are handicraft villages specialising in bamboo weaving and brisk baking. In addition, in the province there are 12 establishments of manual iron casting and steel refining, more than 30 small lead and zinc ore sifting establishments and more than 100 gold sifting establishments. None of these establishments have waste water treatment systems. The waste water contains many heavy metals, harmful chemicals and is directly discharged to sewage systems and then to Cau River.

In Vinh Phuc province there are 16 craft villages majoring in mechanical engineering, carpentry, bamboo weaving and food processing. Most of the waste water from these craft villages is directly discharged to surrounding ponds, lakes, trenches, sewage systems and then flows into Ca Lo River without treatment. This contributes to the pollution of the water source.

**Domestic waste water**

The population in provinces of Cau river basin, especially in urban areas, is increasing. The population is growing rapidly while the urban technical infrastructure is incompatibly developed. This leads to an increase in pollution caused by domestic waste water. Most of the domestic waste water is directly discharged to rivers, lakes and the river basin without treatment.

One of the characteristics of domestic waste water is that it contains a high level of nutrition, BOD and organic nitrogenous compounds; the waste water also contains coliforms, bacteria, and infectious diseases. In Cau river basin, urban areas tend to be located along rivers. Domestic waste water is usually discharged directly to the rivers and cause direct and serious impacts on water quality.

It is estimated that of the relevant provinces in Cau river basin, Hai Duong contributes the highest volume of domestic waste water (comprising 25% of the total volume). Fortunately, Hai Duong is located in the downstream section of Cau river basin, therefore its domestic waste water does not affect the water quality of the rest of the basin (Figure 2.11).
Hospital waste water

According to statistical figures for 2005, there are more than 1,200 medical establishments with 15,400 patient beds in provinces of Cau river basin. The total volume of waste water is estimated at 5,400 m³/day of which, only some hospitals have waste water treatment systems. However, most of these systems are not in operation or in inefficient operation. Therefore most of the waste water is directly discharged to water sources carrying with it harmful chemicals, organic substances and pathogenic bacteria.

<table>
<thead>
<tr>
<th></th>
<th>Vinh Phuc</th>
<th>Bac Ninh</th>
<th>Hai Duong</th>
<th>Bac Kan</th>
<th>Thai Nguyen</th>
<th>Bac Giang</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD (ton/day)</td>
<td>83 - 119</td>
<td>71 - 101</td>
<td>122 - 174</td>
<td>21 - 30</td>
<td>79 - 112</td>
<td>112 - 161</td>
<td>488 - 697</td>
</tr>
<tr>
<td>BOD (ton/day)</td>
<td>52 - 62</td>
<td>44 - 53</td>
<td>76 - 92</td>
<td>13 - 16</td>
<td>49 - 59</td>
<td>70 - 85</td>
<td>304 - 367</td>
</tr>
<tr>
<td>Total nitrogen (ton/day)</td>
<td>7 - 14</td>
<td>6 - 12</td>
<td>10 - 20</td>
<td>2 - 4</td>
<td>7 - 13</td>
<td>9 - 19</td>
<td>41 - 82</td>
</tr>
<tr>
<td>Total phosphor (ton/day)</td>
<td>0.5 – 4.6</td>
<td>0.4 - 4</td>
<td>0.7 - 7</td>
<td>0.2 – 1.2</td>
<td>0.4 - 4</td>
<td>0.6 - 6</td>
<td>2.8 - 26.8</td>
</tr>
<tr>
<td>Coliform (10¹² bacteria/day)</td>
<td>1,155</td>
<td>987</td>
<td>1,698</td>
<td>295</td>
<td>1,095</td>
<td>1,564</td>
<td>6,794</td>
</tr>
<tr>
<td>Oil (ton/day)</td>
<td>11</td>
<td>10</td>
<td>17</td>
<td>3</td>
<td>11</td>
<td>14</td>
<td>66</td>
</tr>
<tr>
<td>SS (ton/day)</td>
<td>196 - 254</td>
<td>168 - 217</td>
<td>289 - 374</td>
<td>50 - 65</td>
<td>186 - 240</td>
<td>266 - 344</td>
<td>1,155 – 1,494</td>
</tr>
</tbody>
</table>

(The estimation is calculated based on the method introduced by the WHO. The population is according to the Statistical Year Book, 2005)

Box 2.3. Hospital waste water treatment in medical establishments of Thai Nguyen province

At the moment there are 200 medical establishments operating in Thai Nguyen province. However, Thai Nguyen Policlinic is the only medical establishment that has a central waste water treatment system. No waste water treatment systems are in place in the other establishments. In these cases the waste water is directly discharged to the environment. This is a source of environmental pollution and disease transmission to the surrounding communities.

Source: Thai Nguyen DONRE, 2006

Figure 2.12. Hospital waste water contribution of related provinces in Cau river basin estimated based on the number of patient beds

Source: Statistical Year Book, 2005
Agricultural activities

Agricultural activities are important in relevant provinces in Cau river basin. Beside traditional grain plants, the provinces focus on the development of plant species which are considered most suitable for each specific province. In order to increase the production yield, agricultural pesticide and chemical fertilizers are increasingly used. Pesticide is sprayed 3 or 5 times during an individual rice or tea crop.

The average quantity of agricultural chemicals used in the provinces is 3kg/ha/year, of which pesticide contributes the largest portion (68.3%). (Figure 2.13). At the moment, chemical fertilizers and pesticide are widely used in all agricultural areas of the river basin. The average amount of fertilizers used is reaching 500,000 ton/year and pesticide is 4,000 ton/year, 33% of which remains and is discharged into the basin (primary estimation for 1999).

Beside rice as the main grain plant, perennial horticultural plants, especially litchi and longan, are given focus in Bac Giang province. The amount of agricultural chemicals used is estimated at 145 tons/year (Bac Giang Provincial Report on the State of the Environment, 2005).

The total amount of agricultural chemicals used in Bac Ninh province includes 1,200 tons of pesticide and 200,000 - 300,000 tons of N.P.K fertilizers. In areas where intensive vegetable farming is practiced, the amount of pesticide and chemical fertilizers used is 3 to 5 times higher than that of rice farming areas. At present, the province encourages the shift to using biological fertilizers and pesticides, applying the comprehensive farming and epidemic prevention practice.

Animal and poultry husbandry in related provinces in the river basin is steadily growing (Figure 2.14). However, solid and liquid waste treatment measures are applied only to a very limited extent in some farms. Therefore, most of the waste,
especially waste water, is directly discharged to surface water sources.

**Solid waste**

According to statistics, the provinces in Cau river basin generate about 1,500 tons of urban waste a day, the major part of which is domestic waste.

The collection rate of solid waste in the whole basin is rather low, estimated at 40 - 45%. In urban areas, the collection rate is higher - at 60 - 70%. In most of the provinces there are no hygienic landfill sites nor waste leachate treatment systems. A significant proportion of waste is not collected and treated but instead disposed of at road sides, trenches, sewage systems or even to rivers and streams. This is a potential source of pollution to surface water and ground water sources in Cau river basin.

The amount of hazardous industrial waste and medical waste is much less compared to domestic waste, but these types of waste require most attention as they have very serious impacts on the environment and human health unless effective management measures are in place. However, at present, most of these types of waste are not classified nor treated as regulated.

**Figure 2.15. Urban domestic waste in relevant provinces in Cau river basin, 2004**

*Source: Reports on the State of the Environment of the relevant provinces, 2005*

**Table 2.4. Medical waste volume in some relevant provinces in Cau river basin, 2004**

<table>
<thead>
<tr>
<th>Province</th>
<th>Kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thai Nguyen</td>
<td>350</td>
</tr>
<tr>
<td>Vinh Phuc</td>
<td>141</td>
</tr>
<tr>
<td>Bac Ninh</td>
<td>438</td>
</tr>
<tr>
<td>Hai Duong</td>
<td>613</td>
</tr>
</tbody>
</table>

*Source: Reports on the State of the Environment of the relevant provinces, 2005*
2.2.3. Pollution forecast

According to the approved socio-economic development plans of the provinces, it is estimated that by 2010 the waste water discharged to Cau River will have doubled the current volume.

The environmental pollution level of Cau river basin has been calculated based on three scenarios: (1) Scenario 1: The waste water volume in the basin increases according to the planning data but is not treated; (2) scenario 2: The waste water volume in the basin increases according to the planning data with 30% of which is treated; (3) scenario 3: The waste water volume in the basin increases according to the planning data and is treated to meet environmental standards.

According to the scenario 1, it is noticeable that the economic development if it is not accompanied by environmental protection will lead to the severe depletion of the surface water quality: the average BOD concentration will increase by 1.5 times and even by 1.8 times at some typical points like Quan Trieu ward, Thai Nguyen city; the average total nitrogen will increase by 1.3 times; the average total phosphor will increase by 1.2 times even by 1.5 times in some places like Van Yen (Yen Phong - Bac Ninh); the average coliform concentration will increase by 1.3 times.

For scenarios 2 and 3, the estimation shows that if the waste water is treated to a certain level the water quality in Cau river basin will be considerably improved; the quality indicators of the water will nearly meet the TCVN 5942-1995 type A, this means the surface water can be supplied for domestic use purposes.
2.3. NHUE-DAY RIVER BASIN

2.3.1 The current state of the pollution

The surface water environment of Nhue-Day river basin is suffering from strong impacts of waste water from domestic, industrial, agricultural and aquaculture activities in the region. At the moment, water quality in many river sections in Nhue-Day river basin have been polluted to an alarming level. The main pollutants to the river are organic substances, nutrition, suspended substances, bad odour, dark color and bacteria. Especially in the dry season, the water environmental pollution tends to worsen.

Rivers in the inner part of Hanoi have been severely polluted

The surface water in rivers in the inner part of Ha Noi has been severely polluted. All parameters have exceeded permitted standards for surface water (TCVN 5942-1995, type B) by many times, typically, in some places they have exceeded standards for domestic waste water (TCVN 6772-2000, level IV). In the dry season, the quality deteriorates even further. The monitoring results conducted in late 2005 show that the DO value was very low; the COD content exceeded permitted standards by 7-8 times; the BOD$_5$ content - 7 times (Figure 2.19); the coliform concentration was higher than TCVN 5942-1995 (type B).

Most of the rain water together with waste water from domestic and production activities of Hanoi is discharged to rivers in the inner part of the city. This water then outflows to To Lich and Nhue River (through Thanh Liet dam). Recently Yen So conditioning lake has come into operation. It receives the major part of the waste water of Hanoi and pumps to Hong River. This lake operates mainly in the dry season, however, during the rainy season water from To Lich River is discharged to Nhue River with a high concentration of pollutants.

Nhue River is severely polluted after receiving water from To Lich River

In the upstream area (at the confluence with Hong River) the water is almost unpolluted, however, the water in the section flowing through Ha Dong (Phuc La) to the confluence point with To Lich River has been polluted: the COD, BOD$_5$ contents have exceeded the standards (TCVN 5942-1995) by 3 - 4 times; the water has a black color with scum, sludge and fishy smell.

After receiving waste water from To Lich River, Nhue River has become...
severely polluted especially in the dry season, when the water volume from Hong River flowing into Nhue River decreases. In the rainy season, although Nhue River receives a supplementary volume, the typical pollution parameters such as BOD$_5$, COD, SS and nitrogenous, phosphorus compounds and coliforms in the water are still higher than TCVN 5942 - 995 (type B).

Along the river section from the confluence point with To Lich River to the downstream (where it merges with Day River), the pollution level of Nhue River water decreases due to the self-purifying process, however it is still higher than TCVN 5942 - 1995 (type B).

In recent years, in the dry season, the water from To Lich River has been channeled to Yen So conditioning lake and then pumped to Hong River. Nevertheless, the pollution level in Nhue River still shows an increasing trend. Figure 2.21 shows the obvious increase in COD content over years.

**Day River is locally polluted with the pollution level tends to increase, especially as the river is affected by the pollution from Nhue River**

From Ha Dong (Ha Tay) to Phu Ly town (Ha Nam) Day River is polluted by organic substances with the pollution levels varying from one section to another. The typical parameters of organic pollution in the river sections flowing through Ung Hoa, My Duc (Ha Tay), Kim Bang, Phu Ly (Ha Nam) have all exceeded TCVN 5942 - 1995 (type A) (Figure 2.22).

At Hong Phu bridge (Phu Ly, Ha Nam - the confluence of Nhue, Day and Chau Giang Rivers) the water is polluted with a relatively high level of organic pollutants, especially in the dry season (from November to March of the following year). The parameters such as BOD$_5$, COD, nitrogenous compounds and coliforms do not meet TCVN 5942-1995 (type A) (Figure 2.23).
The river section from Phu Ly town to the confluence of Hoang Long and Day Rivers (at Gian Khau bridge - Gia Vien - Ninh Binh): beside the impacts of Nhue River, this section is also affected by domestic and industrial waste water discharged from Phu Ly town. The water is relatively severely polluted (the BOD$_5$ content exceeds TCVN 5942-1995 type A by two to three times). Although in this section, the river receives supplementary water from Hoang Long River, however the water is not much improved as the Hoang Long River is already polluted after flowing through Hoa Binh and Ninh Binh (Gia Vien).

The river section from Gia Vien to Kim Son (Ninh Binh) is polluted by organic substances: some parameters do not meet TCVN 5942-1995 type A (for instance, BOD$_5$ content exceeds the standard by two to three times), nor even the standard type B at some points.

The Day downstream section (from Kim Son - Ninh Binh to Day estuary): Although the polluted water from the upstream has been diluted by supplementary water and through the self-purifying process of the river, the water is not much improved compared to the upper sections due to pollution sources along the river banks. The pollution parameters do not meet TCVN 5942-1995 type A, although standard type B is met at some points.

Thus, the water quality of Day River has a complicated trend of development. From both spatial and time-bound perspectives, the pollution level of Day River is lower than that of Nhue River. However, Day River water quality shows a decreasing trend in recent years (Figure 2.25).

Other rivers in the basin have also shown signs of quality depletion

Tich River is polluted by organic substances (organic pollution parameters have exceeded TCVN 5942-1995 type A) as it receives waste water from production and domestic activities of Son Tay town, waste water from Hoa Lac area - an area of dynamic urban development - and water from Bui River, while Bui River is also polluted as it receives waste water from production and domestic activities of Luong Son, Hoa Binh.

Chau Giang River is polluted and the pollution shows an increasing trend (Figure 2.26). This river merges with Day and Nhue Rivers at Phu Ly. However, as it receives water from Hong River, the river estuary has a high level of deposited alluvial and the river is affected by irrigation discharge and water from Nhue and Day rivers.

Hoang Long River is polluted by organic substances at a relatively high level at the
confluence with Day River (Figure 2.27), after flowing through Hoa Binh, Nam Dinh and Ninh Binh.

Dao River (the main water source for downstream of Day River) is slightly polluted by organic substances at some places. The water quality of Dao River shows a deteriorating trend (Figure 2.28).

2.3.2. Causes of pollution

There are many waste water sources that pollute Nhue-Day river basin. This section presents the sources of pollution, from the highest polluter down to the least. The pollution sources are presented in the following order: domestic waste water, hospital waste water, industrial waste water, agricultural waste water and craft village waste water, etc.

Of the pollution sources with highest pollution volume in Nhue - Day river basin, domestic waste water contribute the largest part (56%). This is an unique feature of Nhue - Day river basin compared to other river basins (Figure 2.29).

**Domestic waste water**

Domestic waste water with high volume and high organic pollutant content have made the water quality of Nhue River and some sections of Day River severely polluted by organic substances. Of the provinces and cities in the basin, Hanoi contributes 54% of the total domestic waste water, followed by Ha Tay with 17% (Figure 2.30).
With the high average population density (3.5 times higher than the national average) and high population growth, the waste water volume in Nhue - Day river basin is consequently increasing. The rapid urbanization, accompanied by the incompatibly developed urban technical infrastructure, has led to the increased pollution resulted from domestic waste water.

Most of the domestic waste water is directly discharged to rivers, lakes in the river basin without treatment. This is one of the most important causes leading to the increased water pollution of the Nhue - Day river basin.

### Hospital waste water

Hospital waste water is a hazardous source that should be completely treated before discharging to receiving bodies. However, to date most of medical establishments have no waste water treatment systems (Box 2.4). The waste water is directly discharged to the receiving bodies and then to surface water sources of the river basin.

At the moment, in the whole basin, there are 26,300 patient beds (of which Ha Noi contributes 47%) in 1,400 medical establishments, with the average waste water of 100,000 m³/day.

### Box 2.4. Hospital waste water treatment in Ha Nam

According to statistics, there are 147 medical establishments in the province. However, most of the establishments have no waste water treatment systems, except for the Provincial Clinic (where the waste water treatment has a treatment capacity of 400 m³/day and uses microbiological technology) and Binh Luc District Clinic (with treatment capacity of 200 m³/day).

*Source: Ha Nam DONRE, 2006*

### Table 2.5. Estimated load of pollutants contained in domestic waste water discharged to Nhue - Day river basin, 2005

<table>
<thead>
<tr>
<th></th>
<th>Ha Noi</th>
<th>Ha Tay</th>
<th>Ha Nam</th>
<th>Nam Dinh</th>
<th>Ninh Binh</th>
<th>Hoa Binh</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD (ton/day)</td>
<td>226 - 323</td>
<td>182 - 259</td>
<td>59 - 84</td>
<td>141 - 201</td>
<td>66 - 94</td>
<td>59 – 84</td>
<td>733 - 1045</td>
</tr>
<tr>
<td>BOD₅ (ton/day)</td>
<td>142 - 170</td>
<td>114 - 136</td>
<td>37 - 44</td>
<td>88 - 106</td>
<td>41 - 50</td>
<td>37 - 44</td>
<td>459 - 50</td>
</tr>
<tr>
<td>Total nitrogen (tons/day)</td>
<td>19 - 38</td>
<td>15 - 30</td>
<td>5 - 10</td>
<td>12 - 24</td>
<td>6 - 11</td>
<td>5 – 10</td>
<td>62 - 123</td>
</tr>
<tr>
<td>Total phosphor (ton/day)</td>
<td>1 - 13</td>
<td>1 - 10</td>
<td>0.3 - 3</td>
<td>0.8 - 7</td>
<td>0.4 - 3</td>
<td>0.3 – 3</td>
<td>4 - 39</td>
</tr>
<tr>
<td>Coliform (10¹² bacteria/day)</td>
<td>3,145</td>
<td>2,526</td>
<td>823</td>
<td>1,961</td>
<td>919</td>
<td>813</td>
<td>10,187</td>
</tr>
<tr>
<td>Oil (ton/day)</td>
<td>31</td>
<td>25</td>
<td>8</td>
<td>19</td>
<td>9</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>SS (ton/day)</td>
<td>535 - 692</td>
<td>429 - 556</td>
<td>140 - 181</td>
<td>334 - 431</td>
<td>156 - 202</td>
<td>138 - 179</td>
<td>1,732-2,241</td>
</tr>
</tbody>
</table>

*The estimation is calculated based on the method introduced by the WHO. The population is according to the Statistical Year Book, 2005*
Industrial waste water

According to statistics, to 2004, in Nhue - Day river basin there were 4,113 industrial enterprises (of which Ha Noi contributed 67% of the total); the industrial production was VND 83,382 billion (The General Statistic Directorate, 2005). Production activities generate a huge amount of waste (solid, liquid and airborne) which causes pollution and has great impacts on the environment of Nhue - Day river basin. This pollution is an important factor that depletes the surface water quality of water bodies in the region.

Taking waste water volume into account, Ha Noi generates the largest part, (about 100,000 m³/day, comprising 30% of the total), followed by Ha Tay (80,000 m³/day, comprising 25% of the total).

According to the recent surveyed results, of the 218 production establishments that are main waste water generators in Nhue - Day river basin, the mechanical industry contributes the largest portion (33%) (Figure 2.33). Waste water of different industries has different features and levels of impact on water quality. Waste water from the mechanical industry contains much oil and suspended solids (SS), while waste water from the food processing sector contains many organic compounds. Waste water from textile and dying industry contains many chemicals such as alkali, detergent, aluminum, pine resin and artificial coloring agents which are harmful to the environment.

Figure 2.32. Portion of industrial production enterprises per provinces and cities in Nhue - Day river basin
Source: General Statistical Office, 2005

Figure 2.33. Production establishments per main waste generating industries in Nhue - Day river basin
Source: Institute of Geography, 2005

Box 2.5. Waste water volume of some industrial sectors of Ha Noi
- Textile and dying establishments: 14,500-17,210 m³/day
- Food processing plants: 13,870-16,010 m³/day
- Chemical factories: 24,500-26,540 m³/day
- Mechanical factories: 3,730-4,500 m³/day

Agricultural production activities

About 60-70% of the total population in Nhue - Day river basin participates in agricultural production activities.

Farming: rivers in Nhue - Day river basin serve as an inter-provincial irrigation system supplying water for agricultural production in the whole region. The flow regimes are significantly dependent on the system of conditioning sewages in the basin. The operation regime of this system has strong impacts on the water quality of the basin (especially the irrigation system of Nhue River).

In addition, the improper use of chemical fertilizers and pesticide in agricultural practice also affect the water quality.

Animal Husbandry: as animal husbandry is encouraged in Nhue - Day river basin, the number of animals is continuously increasing over time (Figure 2.34). The increase in number of animals naturally leads to the increase in waste water volume (Box 2.6).

Box 2.6. Waste water from animal husbandry activities
With a stock of 10,000 animals to produce 1,000 tons of pig meat, each year the husbandry sector generates 10,000 - 20,000 tons of excrement, 20,000 - 30,000 m³ of urine and 50,000 - 200,000 m³ of waste water from cleaning of the breeding facility.

Source: Institute of Environmental sciences and technologies, 2004

Table 2.6. Statistical data on the number of main waste generating industries in Nhue - Day river basin per sectors and provinces

<table>
<thead>
<tr>
<th>Province</th>
<th>Mechanical industry</th>
<th>Food processing industry</th>
<th>Textile and dyeing industry</th>
<th>Chemical and paper industry</th>
<th>Construction material industry</th>
<th>Other sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of estbl.</td>
<td>%</td>
<td>No. of estbl.</td>
<td>%</td>
<td>No. of estbl.</td>
<td>%</td>
</tr>
<tr>
<td>Hanoi</td>
<td>45</td>
<td>64.28</td>
<td>10</td>
<td>30.3</td>
<td>17</td>
<td>58.62</td>
</tr>
<tr>
<td>Ha Tay</td>
<td>11</td>
<td>15.71</td>
<td>9</td>
<td>27.27</td>
<td>6</td>
<td>20.69</td>
</tr>
<tr>
<td>Nam Dinh</td>
<td>9</td>
<td>12.86</td>
<td>2</td>
<td>6.06</td>
<td>6</td>
<td>20.69</td>
</tr>
<tr>
<td>Ninh Binh</td>
<td>3</td>
<td>4.28</td>
<td>4</td>
<td>12.12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ha Nam</td>
<td>1</td>
<td>1.43</td>
<td>5</td>
<td>15.15</td>
<td>1</td>
<td>3.45</td>
</tr>
<tr>
<td>Hoa Binh</td>
<td>1</td>
<td>1.43</td>
<td>3</td>
<td>9.09</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>100</td>
<td>33</td>
<td>100</td>
<td>29</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Institute of Geography, 2005

Figure 2.34. Number of domestic animals (buffaloes, cows, pigs) of provinces in Nhue - Day river basin over years
Source: Statistical Year Book, 2005
However, to date, even in large animal husbandry facilities the investment in environmental treatment is still limited. Therefore, most of the waste, especially waste water, is discharged to surface water sources, leading to serious environmental pollution.

**Waste water from craft villages**

According to statistics of the relevant provincial departments of Natural Resources and Environment, there are 458 craft villages in the whole basin. On one hand, these craft villages bring about a considerable economic value to the region, on the other hand, however, they also contribute to increasing the environmental pollution in the basin. Production activities of the craft villages generate about 45,000 - 60,000 m$^3$ of waste water a day (of which the craft villages of Ha Tay contribute 40% of the total volume).

Most of the small production establishments in craft villages are developed spontaneously to meet the market demands. They are characterized by simple equipment, outdated technologies, small workplaces and limited investment in waste water treatment facilities. The waste water from these craft villages is usually discharged to receiving sources without prior treatment. This leads to severe pollution of the surface water sources. Some investments have been made in building central waste water treatment facilities for some villages, however the effectiveness has been low (Box 2.8).

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**Figure 2.35. Distribution of craft villages in provinces/cities in Nhue river basin**

*Source: DONREs of provinces/cities in Nhue - Day river basin, 2006*

**Box 2.7. Waste water volume from some craft villages in Nhue - Day river basin**

Eleven craft villages in Ha Dong and Hoai Duc district, Ha Tay province alone generate 15,000 - 18,000 m$^3$ of waste water a day. The waste water is directly discharged to the sewage system and then to Nhue river without prior treatment.

The total waste water volume of craft villages locating along Nhue river in Ha Nam province is estimated at about 20,000 - 30,000 m$^3$/day.

*Source: Department of Environment, MONRE, 2004*

**Box 2.8. The current situation of waste water treatment in Ha Tay province**

There are 219 villages in Ha Tay province. However, except for Cat Que - Minh Khai where a central waste water treatment plant has been constructed (without equipment yet), in all remaining craft villages there are either no waste water treatment facilities or in some there are just pilot models. This has become one of the most acute problems for which Ha Tay has not yet found an effective solution.

*Source: Ha Tay DONRE, 2006.*
The surface water pollution caused by production activities of craft villages in Nhue - Day river basin has become relatively severe with different characteristics featuring different type of activity.

Of the craft villages active in the river basin, agricultural food processing villages are among the biggest waste water generators, causing huge impacts to the surface water environment of the basin. Some typical examples are:

* Cat Que village, Hoai Duc (producing malt, vermicelli, sugar, dry rice pancake): 3,500 m³/day.

* Duong Lieu village, Hoai Duc (producing vermicelli, starch): 6,800 m³/day.

* Minh Khai village, Hoai Duc (producing vermicelli, starch): 5,500 m³/day.

(Source: Ha Tay provincial Department of Natural Resources and Environment, December 2005)

In most of the craft villages in the basin the water quality parameters have exceeded permitted standards by many times. However, the pollution by waste water from craft villages is often local. The waste water from craft villages comprises 4% of the total waste water of the whole basin.

Box 2.9. Water pollution caused by different production activities of craft villages in Nhue - Day river basin

Waste water from agricultural food processing establishments contains many pollutants, most of which are organic substances. The content of the pollutants have exceeded permitted standards TCVN by many times. The average content of $\text{BOD}_5$ is 380-400 kg/ton of products and of COD is 600-650 kg/ton of products.

Weaving and dying establishments use high volume of chemicals. The waste water from this type of activity has dark color and high volume of chemical residue. The average content of COD is 81 kg/ton of products and of TS is 300 kg/ton of products.

The waste water from mechanical production establishments using metal plating agents contains metal with a content exceeding the TCVN by many times: Cr(VI): 420 times; Cr(III): 18-100 times; Pb: 6-24 times; Zn: 6-32 times.

The waste water from construction material production establishments contains high content of suspended solids, which is 1.3 - 7.3 times higher than TCVN; and the concentration of $\text{SO}_4$ is 300 - 400 times higher than TCVN.

(Source: The Study on “Applying some technological and management solutions for small industries in order to improve the environmental quality of Nhue - Day river basin”, 2003)
Solid waste

Solid waste is one of the polluting sources of the surface water in the basin. Accompanying with the development of economic sectors, the urbanization and the population growth, the total amount of solid waste in the basin has been continuously increasing (especially in urban areas). Of the total amount of solid waste, domestic waste comprises 80%, the rest is waste from industrial production establishments.

Although they are small in amount, industrial and hospital wastes are hazardous and harmful to the environment and human health unless proper treatment procedures are in place.

The average waste collection rate is rather low. In rural area, the collection rate in very low (averaging at 20%). In big cities the collection rate of domestic solid waste is higher. Solid waste is often thrown away in an indiscriminate manner or piled on river or lake banks, resulting in pollution of the surface water in the basin.

At present the collection and transportation of urban and industrial solid waste has not yet met requirements. Except for Nam Son Landfill site of Ha Noi, other landfill sites in Nhue - Day river basin are using outdated burying technologies leading to surface and ground water pollution in the basin.
2.3.3. Pollution forecast

According to surveys conducted to serve the socio-economic development planning of provinces in the river basin, it is forecasted that to 2010 the volume of waste water will continue to increase, especially that of Ha Noi Capital and Ha Tay province. It is estimated that by 2010 the waste water volume of Ha Noi will have increased by 1.2 times; and of Ha Tay will have increased by 1.9 times compared to that of 2005.

In order to calculate the threats and the levels of pollution in river basins, 3 scenarios have been chosen: (1) **Scenario 1**: The waste water volume in the basin increases according to the planning data but is not treated; (2) **scenario 2**: The waste water volume in the basin increases according to the planning data with 30% of which is treated; (3) **scenario 3**: The waste water volume in the basin increases according to the planning data and is treated to meet environmental standards. The calculated results are presented in Figures 2.39, 2.40 and 2.41.

In case appropriate environmental measures, such as treating waste water prior to discharging it to rivers, are not in place, by the year 2010 the water quality of Nhue - Day River will have deteriorated: the BOD concentration will have increased by 1.2 - 1.5 times; total nitrogen - 1.2 to 1.85 times; total phosphor - more than twice, total coliform - 1.3 times to more than twice.
Chapter 2: THE ALARMING POLLUTION AT THE 3 RIVER BASINS

2.4. DONG NAI RIVER SYSTEM BASIN

2.4.1 The current state of the pollution

With the development areas of many provinces being spread along its length, Dong Nai river system basin has been severely impacted by pollution sources throughout the basin. The downstream areas of many rivers in the basin have been seriously polluted, including many river sections which have become “dead” rivers.

Many parts of Dong Nai River have been seriously polluted, especially in downstream areas

The water of Dong Nai River, especially the section from Thien Tan Water Plant to Long Dai - Dong Nai has been polluted by organic and suspended solid substances; especially lead concentration has exceeded the Vietnam Standard TCVN 5942 - 1995 for type A. In this river section, the suspended solid substances are often 3-9 times higher than the Standards, COD values are 1.8 - 2.8 times higher than the Standards, and DO value is often lower than permitted limits.

The water quality of the part from Hoa An water pumping Station to Cat Lai Station, via Ho Chi Minh city area, has remained stable during the period from 2001 until now; the BOD₅ content varies about 2 mg/l which is within the permitted standards for surface water quality for domestic use. The oil concentration is around 0.025 - 0.029 mg/l, while the Vietnamese Standards provide that oil is not allowed in water sources used for domestic supply. High micro organic pollution occurred in areas of Hoa An and Cat Lai, but the pollution has shown a reducing trend in recent years (Figure 2.42).

River water quality in downstream areas:
The DO value sharply reduces, SS content is 2-2.5 times higher than Vietnam Standards TCVN 5942 - 1995 (type B). This area is also seriously salinized, and the river water could not be used for domestic and agricultural purposes.

Sai Gon River system has been seriously polluted mainly by organic pollutants, coliforms and heavy metal pollution in some areas

The water quality in the middle parts of the river system such as in Ben Suc bridge, Thi Tinh River mouth, etc. is locally polluted by organic substances. The monitoring results of the area shows that the DO value is low, N-NH₄⁺ is higher than Vietnamese Standards TCVN 5942-1995 (type A). In Thi Tinh River mouth, the N-NH₄⁺ is nearly 30 times higher than Vietnamese Standards.

The river water is polluted from Thi Tinh River mouth and gradually increases moving downstream. The degree of pollution has also increased in recent years. The monitoring results show that the pH and DO values have sharply reduced, especially in the areas adjacent to An Loc bridge, An Ha area (Ho Chi Minh City), where the DO value does not meet Vietnamese Standards TCVN 5942 - 1995 (type B).
The water quality monitoring results from 2000 until now of Phu Cuong, Binh Phuoc and Phu An, Sai Gon River in Ho Chi Minh City Monitoring Stations show that the river water of these areas have been polluted by organic substances, especially by oil and coliforms. The DO value varies from 0.7 to 2.7 mg/l, which does not meet the standards of a surface water source used as a supply for domestic use as stipulated by Vietnamese Standards TCVN 5942-1995 (type A). The BOD$_5$ value, which varies from 0.7 to 2.7mg/l, also does not meet the standards of a surface water source used as a supply for domestic use (Figure. 2.44).

This area has also been polluted by high concentration of coliforms, which is from 3 to 168 times higher than the permitted standards. There is an increasing trend in pollution from the upstream sections, in Phu Cuong area, toward the downstream, in Binh Phuoc and Cat Lat stations (Figure 2.45).

These areas has also been polluted by high concentration of coliforms, which is from 3 to 168 times higher than the permitted standards. There has been a increasing tendency from the upstream, in Phu Cuong area, toward downstream, in Binh Phuoc and Cat Lat stations (Figure 2.45).

In areas of Nha Be - Can Gio (upstream of the confluence of Sai Gon River and Dong Nai River), Nha Be and Ly Nhon (along Nha Be River), Tam Thon Hiep (along Dong Tranh River) and Vam Co (Vam Co River mouth), the river water quality in Nha Be - Can Gio areas has no organic pollution. DO and BOD$_5$ values still meet Vietnam Standards TCVN 5942-1995 (type B). The oil pollution degree has tended to decrease in recent years. Coliform pollution is still high however and is showing a trend of increasing in comparison with previous years at the same time.
The water quality of other rivers in the basin has also deteriorated

The water quality of some other tributary rivers such as Be River, Da Nhím - Da Dung River in the downstream sections has shown a deteriorating trend. The Fe content in Be River is high, from 10 to 12.5 times higher than Vietnamese Standards TCVN 5942 - 1995 (type A). This makes it difficult to use the river water for domestic purposes. Additionally, the river water has a high turbidity in the rainy season.

Vam Co River has high organic pollution. The measured values of parameters characterizing organic pollution are high, exceeding the Vietnamese Standards TCVN 5942-1995 (type A). The area at Kenh Xang bridge (Tay Ninh, Vam Co Dong River upstream) is heavily polluted during the last months of the year, DO values are much lower than Vietnamese Standards, while N-NH₄⁺ value is several times higher than Vietnamese Standards TCVN 5942 - 1995 (type A). The river water quality does not meet the standards of water for domestic use.

Being the most polluted area in the basin, a 10 km long section of Thi Vai River is called a "dead" river. This river section is located upstream of the confluence of Suoi Ca - Thi Vai Rivers, about 2 km from My Xuan industrial zone. The river water is seriously polluted by organic substances with blackish brown color and fetid odor in both high and low tidal periods. The DO value is often lower than 0.5 mg/l (the lowest value registered is at Ve Dan port (0.04 mg/l) (Fig. 2.47). With a DO value of nearly zero, biological species are unable to survive. The N-NH₄⁺ parameter is also 3 - 15 times higher than Vietnamese Standards TCVN 5942 - 1995 (type B); Coliform value is in the order of tens to hundreds times higher than Vietnamese Standards TCVN 5942 - 1995 (type B).

The mercury concentration at Ve Dan and My Xuan Port areas is 1.5 - 4 times higher, and zinc value is also 3 - 5 times higher than Vietnamese Standards TCVN 5942 - 1995 (type B).
The system of lakes, ponds, and canals in urban areas along Dong Nai River basin system has been seriously polluted

The surface water pollution in canals and trenches in the inner part of Ho Chi Minh City has become one of the most acute problems in the river basin. In the inner part of Ho Chi Minh City there are 5 main sewerage systems. Most of these canals have been highly polluted by organic substances and coliforms. In the dry season, the pollution becomes extremely serious as the self-purification capacity of rivers is lower than that in the rainy season. Especially, coliform value in most of the canals is very high, from thousands to ten thousands times higher than Vietnamese Standards TCVN 5942-1995 (type B) (Figure 2.49).

Many canals in the city have become waste water canals where BOD$_5$ value is 5-16 times higher than Vietnamese Standards TCVN 5942-1995 (type B) (Figure 2.50). According to the monitoring results, Tan Hoa - Lo Gom river system is the most seriously polluted with DO value of nearly zero, and the situation has existed for nearly ten years now, making the river a dead river that has lost its self-purification capacity. The atmosphere along the canal's banks is seriously polluted with a fetid smell released from the canal, and some canal parts are obstructed by lots of waste.

Many factories, industrial zones and sea port have been built along Thi Vai River

Source: VEPA
2.4.2. Causes of pollution

There are many waste water sources that pollute Dong Nai river basin. This section presents the sources of pollution, from the top polluter down to the least, presenting in the following order: industrial waste water, waste water from mining activities, craft village waste water, domestic waste water, hospital waste water, agricultural waste water, etc.

At the present, Dong Nai river system basin is under significant pressure due to population growth, urbanization, and economic development, especially from the provinces belonging to the Southern Focal Economic Region. Besides, the water environment has been greatly impacted by the irrigation-hydropower development activities, the ever increasing use of chemical fertilizers and vegetation protection substances in agriculture, mineral mining activities, water transportation development, etc.

Among the high volume waste sources, domestic waste water and industrial waste water contribute the biggest share, with very high volume of pollutants.

**Industrial waste water**

According to the statistics, until 2004, there were 9,147 industrial production enterprises (60% of which are in Ho Chi Minh City), of which many are scattered within residential areas. This makes it difficult to manage and control the waste source and waste volume.

Each day the river basin receives about 480,000m³ of waste water from the industrial zones and industrial production establishments scattered throughout the basin.

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**Figure 2.51. Number of industrial production enterprises in provinces/cities in Dong Nai river system basin**

*Source: Statistical Yearbook, 2005*

**Activities of the industrial zones and export processing zones**

Until the middle of 2006, there were 56 industrial zones and export processing zones in operation in the basin area (mainly concentrated in the Southern Focal Economic Region), of which only 21 zones have established centralised waste water treatment systems. The others directly discharge waste water into water sources, thus greatly impacting on the water quality of the receiving sources.

**Box 2.11 The waste water treatment of industrial zones and export processing zones in Ho Chi Minh City.**

According to statistics, every day the industrial zones and export processing zones in Ho Chi Minh City discharge about 30,000m³ of waste water of which, only about 6,000m³/day (equivalent to 20% of the total waste water volume) is treated.

*Source: Ho Chi Minh City’s DONRE, 2006*
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The industrial zones and export-processing zones have contributed a great volume of waste water into the river basin (about 120,000 m³/day), of which the biggest volume is from the industrial zones and export processing zones in Dong Nai province (57.2%), and then Ho Chi Minh City (23%), and Binh Duong province (9%). (Figure 2.52).

The receiving medium of waste water from these industrial zones are the middle and downstream areas of Dong Nai River (Dong Nai, Binh Duong industrial zones), Sai Gon River (industrial zones of Ho Chi Minh City, Binh Duong, and Thi Vai River (industrial zones, deep water port of Dong Nai, Ba Ria - Vung Tau). Together with domestic waste water, waste water from industrial zones, and other industrial establishments have caused serious pollution to the downstream areas of Dong Nai, and Sai Gon rivers. Especially Thi Vai River has been severely polluted (the middle part becoming a "dead" river).

### Table 2.8 Report on the waste water sources from industrial zones of some provinces/ cities in Dong Nai river system basin

<table>
<thead>
<tr>
<th>Province</th>
<th>No. of IZ &amp; EPZ</th>
<th>No.of plants</th>
<th>IZ that have water treatment facilities</th>
<th>Waste water volume</th>
<th>Load of pollutants (kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TSS</td>
<td>BOD₅</td>
</tr>
<tr>
<td>HCM city</td>
<td>15</td>
<td>982</td>
<td>7</td>
<td>27,205</td>
<td>5,923.5</td>
</tr>
<tr>
<td>Dong Nai</td>
<td>17</td>
<td>608</td>
<td>6</td>
<td>67,680</td>
<td>8,316.9</td>
</tr>
<tr>
<td>Binh Duong</td>
<td>12</td>
<td>613</td>
<td>7</td>
<td>10,620</td>
<td>409.7</td>
</tr>
<tr>
<td>Ba Ria-Vung Tau</td>
<td>06</td>
<td>89</td>
<td>1</td>
<td>6,100</td>
<td>298.2</td>
</tr>
<tr>
<td>Long An</td>
<td>05</td>
<td>47</td>
<td>0</td>
<td>1,717</td>
<td></td>
</tr>
<tr>
<td>Tay Ninh</td>
<td>01</td>
<td>68</td>
<td>0</td>
<td>5,000(*)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>56</strong></td>
<td><strong>2,355</strong></td>
<td><strong>21</strong></td>
<td><strong>118,322</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: IER, 2005 (* Estimation)

**Mineral mining activities**

Recently, mineral mining activities have developed significantly in the basin. The metal mineral mining is concentrated mainly in the upstream sections (Lam Dong, Dong Nai provinces), the non-metal mineral mining is concentrated mainly in the downstream sections (Binh Duong, Ho Chi Minh City, Dong Nai, Long An provinces). These mining activities are impacting on the surface water quality (including heavy metal pollution).

Bauxite ore mining (in Lam Dong - Dong Nai upstream), gold mining (about 50 ore occurrences and gold mines are concentrated in the northern part of Dong Nai province, Lam Dong and one southern part of Dak Nong province). The main exploitation method applied in these areas is open - pit mining with primitive manual tools. The mining activities have used hundreds of thousand m³ of water and the digging and panning from tens to hundreds of thousands tons of soil, all discharged into the stream causing pollution of the water source in Dong Nai River.
Sand exploitation: from the alluvial in the downstream areas of the basin (mainly in Dong Nai, Sai Gon, Vam Co Dong, Nha Be and Soai Rap Rivers). The exploitation activities in the downstream areas have had a great impact on the water environment, especially the sand exploitation in Dong Nai River which has led to the land splitting and landslides on both banks of the river.

Waste water from craft villages

According to the statistics in 2002, there were totally 491 craft villages and 291 production enterprises and cooperatives in the Southern Central Part and the South of Vietnam. The craft villages specialize in food processing, sedge mat production, lacquer, rattan and bamboo, pottery, embroidery, weaving, wood processing, metal processing and others. Craft villages specializing in rattan and bamboo processing comprise the biggest part (27.9%), followed by sedge mat production villages (19.4%), wood processing villages (11.2%) and pottery production villages (6.9%), etc.

Most of the handicraft establishments in the craft villages used simple equipment and technology with small production premises and limited investment capacity for waste water treatment system, thus causing serious environmental pollution, with different characteristics.

Domestic waste water

At present, in the whole basin there are 77 urban areas with a population of about 8.4 million people (making 60% of the total population in the basin). The urban zones are unevenly distributed but are mainly concentrated in the Sai Gon river basin. In the areas from the center of Ho Chi Minh City to Thu Dau Mot Town about 6 million people are concentrated. The rapid urbanization accompanied by incompatibly developed urban infrastructure has led to the increased environmental pollution.

The average volume of domestic waste water discharged from urban zones into Dong Nai River system is about 992,000 m³ per day. None of the urban zones along the river basin have any domestic waste water treatment system. This is a great source of waste water that causes environmental pollution, especially organic and coliform pollution, to the basin.

<table>
<thead>
<tr>
<th>Craft village</th>
<th>Address</th>
<th>No. of prod. Households</th>
<th>Waste water volume (m³/year)</th>
<th>Domestic waste water volume (m³/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tra Co cassava processing village</td>
<td>Tra Co, Binh Minh commune, Thong Nhat district, Dong Nai</td>
<td>65</td>
<td>105,480</td>
<td>83,424</td>
</tr>
<tr>
<td>Thuan An pottery village</td>
<td>Hung Dinh commune, Thuan An, Binh Duong</td>
<td>800</td>
<td>-</td>
<td>211,846</td>
</tr>
<tr>
<td>Tan Binh Hiep Lacquer art village</td>
<td>Tuong Binh Hiep, Thu Dau Mot, Binh Duong</td>
<td>200</td>
<td>-</td>
<td>406,698</td>
</tr>
<tr>
<td>Bao Loc silk village</td>
<td>Bao Loc town, Lam Dong</td>
<td>5,000</td>
<td>180,000</td>
<td>4,701,200</td>
</tr>
</tbody>
</table>

Source: Report of the Environmental Technology Center, 2002
In the river basin, the major volume of waste water (77.5%) is from Ho Chi Minh city. Sai Gon River's downstream section which flows through the center of Ho Chi Minh city has been seriously polluted as it receives the biggest volume of domestic waste water of the city.

Dong Nai ranks second in discharging waste water into the basin. Dong Nai river downstream section is the main receiving medium of the waste water, especially the river section passing through Bien Hoa City (receiving 87% of the total waste water volume of the province). The water environment here is heavily polluted by organic substances.

**Hospital waste water**

In most of the hospitals and medical centers in the river basin there are no waste water treatment systems. Where systems do exist, they do not meet the treatment requirements (Box 2.12).

<table>
<thead>
<tr>
<th>Locality</th>
<th>Load of pollutants (kg/day)</th>
<th>TSS</th>
<th>BOD$_5$</th>
<th>COD</th>
<th>N-NH$_4^+$</th>
<th>Total P</th>
<th>Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lam Dong</td>
<td></td>
<td>22,824</td>
<td>14,658</td>
<td>27,138</td>
<td>951</td>
<td>517</td>
<td>2,603</td>
</tr>
<tr>
<td>Binh Thuan</td>
<td></td>
<td>1,000</td>
<td>594</td>
<td>1,074</td>
<td>43</td>
<td>24</td>
<td>90</td>
</tr>
<tr>
<td>Dak Nong</td>
<td></td>
<td>2,972</td>
<td>1,765</td>
<td>3,193</td>
<td>128</td>
<td>72</td>
<td>269</td>
</tr>
<tr>
<td>Binh Phuoc</td>
<td></td>
<td>7,448</td>
<td>4,494</td>
<td>8,170</td>
<td>317</td>
<td>177</td>
<td>707</td>
</tr>
<tr>
<td>Binh Duong</td>
<td></td>
<td>21,209</td>
<td>12,596</td>
<td>22,789</td>
<td>911</td>
<td>511</td>
<td>1,916</td>
</tr>
<tr>
<td>Tay Ninh</td>
<td></td>
<td>14,366</td>
<td>8,695</td>
<td>15,821</td>
<td>613</td>
<td>340</td>
<td>1,377</td>
</tr>
<tr>
<td>Long An</td>
<td></td>
<td>14,994</td>
<td>9,134</td>
<td>16,655</td>
<td>639</td>
<td>354</td>
<td>1,467</td>
</tr>
<tr>
<td>Dong Nai</td>
<td></td>
<td>34,620</td>
<td>22,512</td>
<td>41,820</td>
<td>1435</td>
<td>776</td>
<td>4,082</td>
</tr>
<tr>
<td>HCM city</td>
<td></td>
<td>255,787</td>
<td>175,126</td>
<td>329,857</td>
<td>10,380</td>
<td>5,467</td>
<td>34,461</td>
</tr>
<tr>
<td><strong>The whole basin</strong></td>
<td></td>
<td>375,220</td>
<td>249,574</td>
<td>466,517</td>
<td>15,417</td>
<td>8,238</td>
<td>46,972</td>
</tr>
</tbody>
</table>

**Table 2.11. Concentration of pollutants caused by urban waste water from some provinces/cities in Dong Nai river basin system in 2004**

**Box 2.12. Hospital waste water in Ho Chi Minh City**

According to the statistics, in the whole city there are 109 hospitals and medical entities with a total waste water volume of 17,000m$^3$/day, of which about 13,000m$^3$/day is treated (reaching 78% of the total waste water volume). However, the proportion of hospital waste water being treated to meet Vietnam Standards TCVN 6772-2000 is only 26% of the total waste water volume.

*Source: Ho Chi Minh City’s DONRE, 2006*

Most of this waste water volume is discharged directly into the domestic waste water receiving system and discharges into the surface water resources of the river basin. This is a potential source for transmitting infectious disease through the water environment.

**Figure 2.53. Hospital waste water according to the number of patient beds in the provinces/city in Dong Nai river basin system**

*Source: Statistical Yearbook, 2005*
**Agriculture and aquaculture activities**

**Cultivation:** Dong Nai river basin system has about 1.8 million ha of agricultural land (occupying 48.7% of the total land area of the basin). The cultivation activities have a negative impact on the water environment due to the improper use of fertilizers and vegetation protection substances.

The exploitation and transformation of alum soil in some areas such as Long An, Cu Chi, Binh Chanh (Ho Chi Minh City), together with the use of alkaline fertilizers have led to the increased acidification in Sai Gon and Vam Co Dong Rivers.

**Animal Husbandry:**

Animal Husbandry is extensively developed in Lam Dong, Binh Thuan and Dong Nai provinces (Figure 2.54). The total waste water volume from animal husbandry activities in the basin is about 147,300 m$^3$/day. Most of this waste water is discharged into the surface water sources, causing environment pollution.

**Box 2.13 Exploitation of alum soil in the downstream areas of Dong Nai river system basin**

There are about 351,478 ha of alum soil in the downstream of Dong Nai river system basin, making 24.3% of agricultural land (1,448,667 ha). These alum land areas have been thoroughly exploited for agricultural production. This causes adverse impacts on the water quality in the downstream areas of Sai Gon and Vam Co Dong Rivers.

**Source:** IER, 2005

**Aquaculture:**

To date, fresh water aquaculture has been widely developed in the whole basin (cage fish breeding, fish and shrimp hatching in ponds, lakes, reservoirs, etc.). The total surface water area used for aquaculture of the localities in the whole basin is about 71,800 ha and the aquaculture production yield is approximately 500,000 tons/ year.

Waste water and solid waste from the aquaculture activities are often discharged into water sources without being controlled or treated, considerably impacting the surface water quality in the river basin. Additionally, the inappropriate treatment of significant numbers of dead shrimp and fish has also contributed to serious pollution of the surface water environment.
**Water transportation activities**

In Dong Nai river basin system, there are plenty of large, deep rivers and stable channels, especially in the downstream sections of Dong Nai, Sai Gon, Nha Be, Soai Rap, Vam Co, Thi Vai Rivers, etc. These areas have favorable conditions for the development of waterway transportation and deep port systems in the basin.

At present, the Southern Focal Economic region has a total of 37 small and large ports which can receive ships of 1000-3000 DWT. The strong development of the port system has lead to an increase in the number of ships and boats. This is one of the reasons causing surface water pollution due to the discharge of oil sludge and mineral oil waste. According to several studies, the oil waste generated from the cleaning process of oil transportation tankers comprises about 0.67% of the ship weight. At the moment, the river ships are often cleaned in situ, causing oil pollution in some rivers and channels in the downstream areas of the river basin.

Oil spill incidents have been increasing as a consequence of collision and sinking of oil tankers. The number of oil spill incidents is much greater in coastal provinces such as Ba Ria - Vung Tau as, in addition to waterway transportation, the area is impacted by oil and gas exploitation industrial activities.

**Solid waste**

Population growth has brought about the increase in solid waste quantity, causing overload to the waste dumps. These are also sources of water pollution.

The environmental incidents caused by breakage of the oil pipes to the oil tanks in warehouses along Dong Nai - Sai Gon river have also led to the water environment pollution in the downstream section of the river basin.

**Box 2.14 Oil spill incidents in Ho Chi Minh City in 2003-2005**

The collision between Fortune vessel and An Giang oil tanker on 12 January 2003 caused 388m³ of DO oil spillage.

The sinking of oil tanker Hong Anh of Trong Nghia Ltd Company (due to a storm and large wave) on 20 March 2003 causing 600 tons of FO oil spillage.

The collision of Kasco ship with the pier on 21 January 2005 causing 300m³ of DO oil spillage.

The collision between Ho Tay I ship and Ham Luong boat on 06 April 2005 causing 5.40m³ of DO oil spillage.

*Source: Report on the State of the environment, Ho Chi Minh City, 2005*

**Figure 2.55. Urban waste generated and collected from the provinces/ city in Dong Nai river system basin**

*Source: VEPA, 2004*

**Figure 2.56. Hazardous industrial waste generated in Dong Nai river system basin**

*Source: VEPA, 2004*
There are 73 waste dump sites of different scale in the basin, only some of which, such as Go Cat, Phuoc Hiep (Ho Chi Minh City) waste dump site, and Nam Binh Duong Solid Waste Treatment Complex (in Binh Duong) meet the sanitary requirements of a hygienic landfill.

**Depletion in area of upstream forests**

During the period 1990-2002, the area of upstream forests in Dong Nai river system basin has reduced by 107,300ha, or 8,942ha/year in average. Until now, the remaining area is about 950,000ha (Institute of Natural Resources and Environment, 2003).

The reduction in forest area leads to the increased threats of land erosion and the decrease of water reserving capacity. Rainwater flowing across cultivated agriculture regions carries with it lots of polluting elements (mud, alum, fertilizers and pesticide residues, etc.) and has contributed to the water environment pollution in the river basin.

**Box 2.15. Water pollution caused by leachate waste water from Dong Thach Landfill, Ho Chi Minh City**

Dong Thach Landfill is the second biggest site in Ho Chi Minh City as well as in Vietnam with a total area of 40 ha. As the water resistant membrane is not installed in the landfill, the leachate water from the waste penetrates downward causing pollution of the underground aquifers. The water in the dug and drilled wells 20 km from the surrounding wall of the landfill site has become undrinkable as the water has black color and fetid odor.

Additionally, the leachate from the landfill (mainly from the waste water storage lakes) leaking to the surrounding area has caused damage to the production and domestic activities of local people, i.e. fish, pig, chicken and duck are dying; agricultural productivity is decreased, etc. Almost all of the waste water from the waste storage lakes (about 200,000m$^3$ with average COD concentration of about 40,000 - 50,000 mg/l) which is not treated to meet environmental requirements, penetrates into the underground water strata.

Additionally, incidents such as the breaking of banks of the storage lakes (in 2 June 2000, 17 February 2000 and 23 July 2000) have resulted in a great amount of waste and waste water outflow from the landfill, causing serious pollution to the surrounding environment and great damage to the production and domestic activities of the people living nearby.

*Source: IER, 2004*
Other related impacts

Dong Nai river system basin has the advantage of diverse topography, with steep slopes which is favorable for the early development of hydropower construction. Apart from this, the construction of reservoirs in the upstream sections of the basin serving the purpose of adjusting and distributing water flows for agricultural irrigation, domestic water supply, environment landscaping, etc. have also been significantly developed. However, these activities have impacts on the hydraulic regimes of the downstream sections and consequently influence the sustainability of the coastal sections. These, in turn, cause salt penetration and impact on the self-purification capacity of the various tides and currents.

The features of the currents also have impacts on the receiving and self-purification capacities of the river. The annual average current flow of Sai Gon River is much lower than that of other rivers in the basin meaning the self-purification capacity of the river is much more limited compared to other rivers. The pollution load in Sai Gon River however is many times higher, resulting in the pollution being always of a very high level in Sai Gon River.

Table 2.12. Correlation between current flows, BOD$_5$ load and the self-purification capacity of the main rivers in Dong Nai river basin system

<table>
<thead>
<tr>
<th>River</th>
<th>Average current (m$^3$/s)</th>
<th>BOD$_5$ content (kg/day)</th>
<th>BOD$_5$ load in one m$^3$ of river water (g/m$^3$) (R coefficient)</th>
<th>Rough assessment of the self-purification capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>La Nga river</td>
<td>171.5</td>
<td>7,920</td>
<td>7,920</td>
<td>0.53</td>
</tr>
<tr>
<td>Be river</td>
<td>255.2</td>
<td>5,824</td>
<td>0</td>
<td>5,824</td>
</tr>
<tr>
<td>Sai Gon river</td>
<td>93.5</td>
<td>162,399</td>
<td>12,549</td>
<td>174,948</td>
</tr>
<tr>
<td>Vam Co river</td>
<td>169.7</td>
<td>17,153</td>
<td>280</td>
<td>17,443</td>
</tr>
<tr>
<td>Dong Nai river</td>
<td>871.8</td>
<td>51,327</td>
<td>5,145</td>
<td>56,472</td>
</tr>
</tbody>
</table>

Source: IER, 2005
2.4.3. Pollution forecast

Basing on the socio-economic development planning data of the localities, economic regions in the basin, 3 scenarios have been established for calculating the threat and level of environment pollution in Dong Nai river system basin: (1) **Scenario 1**: the waste water volume in the basin increases according to the planning data but without treatment; (2) **Scenario 2**: the waste water volume in the basin increases according to the planning data with 30% being treated; and **Scenario 3**: all waste water volume discharges into river is treated to meet waste water standards.

The sources causing pollution to Dong Nai river system basin are mainly from domestic waste water and the production, transportation activities, etc. According to the socio-economic development planning data of the provinces in the region, it is predicted that to 2010 the waste water volume discharging into Dong Nai river system basin will have significantly increased (about 1.5 - 1.7 times higher than in 2005). Especially, in Ho Chi Minh City and Dong Nai province, the waste water volume will be much more increased, causing the serious reduction in water quality of the river: BOD$_5$ concentration will be increased by 1.4 times, total nitrogen - 1.3 times, total phosphor - 1.2 times, and 1.5 times in some places, such as in Nha Be area.

Thus, the modeled calculation shows that the water quality in Dong Nai river system will be considerably improved if 30% or all of the waste water is treated to meet the waste water standards.