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Assessment of Pollution Load into Thi Nai Lagoon, Viet Nam and Prediction to 2025

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Abstract: Based on the statistical data of social-economic state and development planning to 2025 of Binh Dinh province, the pollution load from development activities has been calculated by using the environmental rapid assessment method. The results showed that development activities in Binh Dinh province create about 30.7, thousand tons of COD;17.1 thousand tons of BOD; 9.1 thousand tons of Nitrogen; 6.5 thousand tons of Phosphorous and 379 thousand tons of TSS from living activities, aquaculture, industry, farming and land leaching. Until 2025, this amount will be increased 1.4 - 2.6 times. The main pollution sources are from living activities including residents and tourists and livestock farming. Therefore, treatment of waste from these sources is very necessary to minimize the waste amount discharged into the Thi Nai Lagoon.

Keywords: Pollution Load, Pollution Sources, Aquacuture, Indutry, Living Wastewater, Wastewater

I. INTRODUCTION

Thi Nai lagoon which located in Binh Dinh province is a tropical salty brackish lagoon with the area about 5,060ha, the length of over 10km and width of about 4km. The lagoon is poured by dense river network, in which Con river and Ha Thanh river are the largest ones. Con River is over 178km in length with total basin area approximately 3,067km^2 and flow velocity 58.84m^3/s. Ha Thanh river is 58km in length with total basin area of about 580km^2 and flow velocity 13.6m^3/s. Both rivers originate from the high mountains, inclined from east to west. In the rainy season, flood and leaching seriously happens, whereas drought occurs in the dry season.Flow velocity differencebetween two seasons is more than 1,000 times (Geography of provinces and cities in Vietnam, Volume 4).

With the characteristic terrain and hydrological conditions, it is could be said that capable development activities and soil leaching in Quy Nhon city, Tuy Phuoc, An Nhon district, Tay Son district and a part of Nam Vinh Thanh district (Con and Ha Thanh river downstream - the main water supply for the Thi Nai Lagoon).

This article has presented the results of calculating thecurrently pollution load generated from residential sources, industry, aquaculture, livestock farming, soil leaching and prediction to 2025 based on social-economic stateand development planning of Binh Dinh province. Since then, the amount of annual pollutants discharged into Thi Nai Lagoon was estimated. The results of the article could be used as a basis to calculate the self-purification capacity and environmental resistance.

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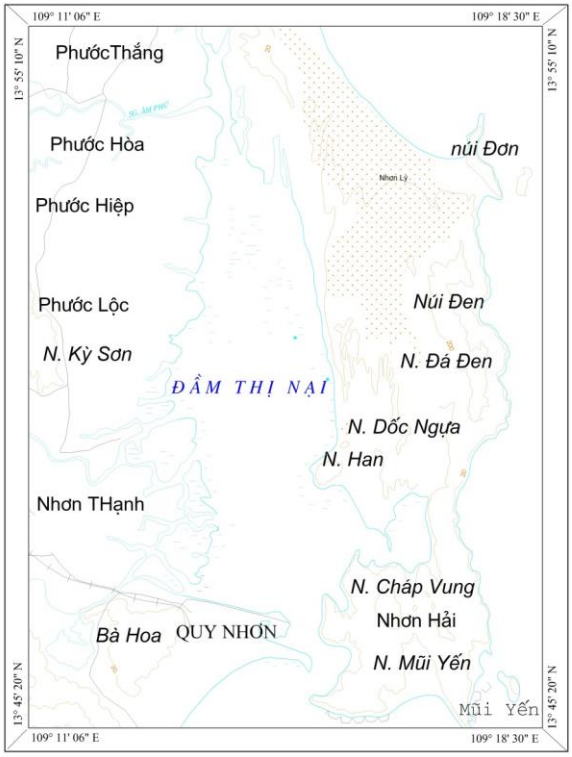

Figure 1. Geographical location of Thi Nai Lagoon

II. DOCUMENTS AND METHODOLOGY

Documents for the calculation include the documents and reports of the aquaculture operation, livestock farming, tourism and development planning of the sectors by 2025:

+ Binh Dinh Statistical Yearbook 2012.
+ Binh Dinh People's Committee, Report on Binh Dinh socio-economic development in 2013, development orientation and tasks in 2014.
+ Resolution No.45/NQ-CP dated 2013 about land use planning until 2020 and land use plans for 05 early years (2011-2015) in Binh Dinh Province issued by Government.
+ Resolution No.06/NQ-HDND dated 2014 about scheme for adjusting the general construction planning in Quy Nhon city, Binh Dinh province and surrounding areas by 2035, vision to 2050.
+ Decision No. 878/QD-UBND dated December 26, 2006 of Binh Dinh People's Committee on the overall planning of industrial development in Binh Dinh province until 2010 and vision to 2020.
+ Decision No. 355/QD-UBND dated June 26, 2007 on approving the adjustment and supplementation of aquaculture overall development planning in Binh Dinh province by 2010 and vision to 2020;
+ Decision No. 54/2009/QD-TTg by the Prime Minister on approving the social - economic overall development planning in Binh Dinh province until 2020;
+ Decision No. 660/QD-UBNDdated 2009 on approving the land use planning in Tuy Phuoc district to 2020 integrating with the environmental protection requirements and climate change issued by Binh Dinh province.
+ Decision No. 52/QD-UBND dated January 19, 2012 of Binh Dinh People's Committee on adjusting and supplementing the industrial parks development planning in Binh Dinh province until 2020 and orientation to 2025.

This research has used the environmental rapid assessment method, calculated pollution load based on the emission factors according to UNEP (1984) [11], San Diego-McGlone (2000) [9], Tran Van Nhan, Ngo Thi Nga (2002) [2] and the number of residents, tourists, animal, industrial production. This method has been used to evaluate the pollution load discharged into Halong Bay - Bai Tu Long [10]. Pollution load discharged into Thi Nai Lagoon has been estimatedby analysing pollutants discharged into the lagoon and waste treatment capability in the region.

*** Pollution from living and tourism activities**

Pollution load which generated from residents in the coastal districts has been caculated by population statisticsin the region and the pollution emission factor per capita. The components which selected for calculating pollution load was BOD, COD, SS, TN and TP. Pollution load from tourists has been calculated based on the number of tourists and residential days multiplied with the pollution emission factor. Pollution load from the districts in Binh Dinh province has been calculated by capability of pollutants discharged into the Thi Nai Lagoon.

Pollution load from living sources (Q_{sh}) is the total pollution load from residents ($\mathbf{Q_{dc}}$) and tourists ($\mathbf{Q_{dl}}$).

$\mathbf{Q_{sh} = Q_{dc} + Q_{dl}}$(tons/year)

- The formula for calculating pollution load from residents

Pollution load from this source has been calculated based on the population of the districts and living pollution load per capita.

$\mathbf{Q_{dc} = P \times Q_i \times 10^{-3}}$

Q_{dc}: Pollution load from residents(tons/year)

P: Population of districts (person)

Q_i: Living pollution load of substance i (kg/person/year)

Table 1. Living pollution load

Parameters	**Pollution load***(kg/person/year)*	**Treatment efficiency**(%)	
		Primary sedimentation	Biotreatment
COD	20 - 55	10 - 20	30 - 60
BOD	10 - 25	10 - 30	50 - 80
N-T	4,0	20 - 40	20 - 50

Parameters	Pollution load*(kg/person/year)*	Treatment efficiency(%)	
		Primary sedimentation	Biotreatment
P-T	0,5 - 1,1	10 - 20	10 - 30
NO_3+NO_2*	0,04	20 - 40	20 – 50
NH_4*	2,2	20 - 40	20 – 50
PO_4*	0,27 - 0,594	10 - 20	10 - 30
TSS	20 - 30	50 - 70	70 - 95

Source: *UNEP, 1984; (*) Figures calculated by San Diego - McGlone, ML, SV Smith and Nicolas V., 2000.*

- The formula for calculating pollution load from tourism activities

Pollution load from tourists has been estimated based on the total number of residential days per year and the living pollution load.

$$Q_{dl} = n \times Q_i / 365 \times 10^{-3}$$

Q_{dl}: Pollution load from tourists (tons/year)

n: total number of residential days of guests per year (day/year)

*** Pollution from industry**

Industrial pollution sources in the region has been calculated based on industrial production yield in related districts multiplied with the pollution emission factor of the industrial type. Industrial pollution load from other areas in the province has been calculated based on capability of bringing pollutants into the areas:

Industrial pollution load has beeb calculated according to the formula:

$$Q_{ij} = \Sigma V_j \times C_{ij} \times 10^{-6} j = 1,n$$

Q_{ij}: Pollution load of substance i from industrial sources j (tons/ year)

V_j: Annual wastewater volume from the facility j (m^3/year)

C_{ij}: Content of substance i in wastewater from facility j (mg/l)

n: The number of industrial facility in the region.

This formula has been used to calculate pollution load from coal industry activities. When there no data on the wastewater composition, pollution load has been calculated based on the volume of some main industrial products of the districts and typical wastewater composition (Table 2).

Table 2.Typicalfood industrial wastewater composition

Parameters	Substance content in wastewater (mg/l)				Treatment efficiency (%)
	Beer	Wheat flour	Cooking oil	Frozen seafood	
m^3/tons of products	11,0	25,0	10,5	95,0	-
COD	150	1500	1950	1950	80 - 85
BOD	87	825	1355	1500	80 - 95
N-T	43,5	42,5	20	90	15 - 50
P-T*	3,65	34,65	56,91	63	10 - 25
NO_3+NO_2*	0,435	0,425	0,2	0,9	8 - 15
NH_4*	16,53	10,2	7,6	34,2	8 - 15
PO_4*	1,825	17,325	28,455	31,5	10 - 25
TSS	<30	1242	95	85	80 - 90

Sourse*: Lam Minh Triet, 1995; (*)Calculated bySan Diego - McGlone, M.L., S.V. Smith and V. Nicolas, 2000; (**)Tran Van Nhan, Ngo Thi Nga, 2002.*

*** Pollution from agricultural sources**

- Pollution from livestock farming

The pollution from livestock farminghas been calculated by the number of livestock and pollution load unit. The number of livestock taken from Binh Dinh Statistical Yearbook. Pollution load unit perlivestockrefered from "Guidance on themaster planning of basin drainage system" - Japanese Drainage Association.

Pollution load by livestock farminghas been calculated based on total annual livestock and pollution load unit for livestock (Table 3).

Table 3.Pollution load unit from livestock farming (kg/year)

No.	Parameter	Poultry*	Cattle	Pig
1	COD	2,73	233,60	73,00
2	BOD	0,78	193,45	47,45
3	N-T	0,5	105,85	14,60
4	P-T	0,156	18,25	9,13
5	NO_3+NO_2*	0,005	1,0585	0,146

No.	Parameter	Poultry*	Cattle	Pig
6	NH_4^*	0,12	25,404	3,504
7	PO_4^*	0,047	8,176	4,110
8	TSS	-	1095,0	255,5

***Source**: "Study on environmental management of Ha Long Bay" JICA, 1999; (*) Calculated by San Diego-McGlone, ML, SV Smith and Nicolas V., 2000*

- Pollution from cultivation:

The amount of pesticides used in agriculture has been known based on the statistics of the Department of Agriculture and Rural Development.

*** Pollution from aquaculture source**

Pollution load from aquaculture source has been calculated based on aquaculture production yield in the region multiplied with the pollutant emission factor for each type of aquaculture production yield. The amount of generated pollutants depends on the form and species farming, in which shrimp and cagefish farming industry has the most significant discharge.

Table 4.Pollution emission factorfrom aquaculture

Parameters	**Pollution emission factor**(kg/ton/year)	
	Shrimp farming	Cage fish farming
COD*	28,4	15,9
BOD*	8,1	4,5
N-T	5,2[a]	2,9[b]
P-T	4,7[a]	2,6[b]
NO_3+NO_2^*	0,05	0,03
NH_4^*	1,25	0,70
PO_4^*	2,12	1,17

Sourse*: (a)- Gonzales J.A., Gonzales H.J., R.C. Sanares and E.T. Tabemal, 1996; (b)- Padilla J., Castro L., Naz. C., 1997; (*)According toSan Diego-McGlone, M.L., S.V. Smith and V. Nicolas, 2000.*

*** Pollution from soil leaching**

Pollution load from soil leaching has been calculated by land use area and pollution load unit. Pollutant load unit per area for BOD, COD, TN and TP refered from "Guidance on the master planning of basin drainage system" - Japanese Drainage Association. Pollution load due to soil leachinghas been calculated based on data on thetypes of land usearea, the average number of rainy days in the area and pollutant load unit from soil leaching of the types of land use.

Table 5.Pollutant load unit from soil leaching (kg/km^2/rainy days)

Parameters	Forest land and grassland	Agricultural land	Cultivated land	Residential land
COD	20	28	26	42
BOD	14	18	16	38
N - T	10	36	32	20
P - T	4	8	6	12
TSS	200	2500	2500	200

Source: "Research on Environmental management in Ha Long Bay" JICA, 1999

*** Estimating pollutant load discharged into the Thi Nai Lagoon**

Pollution load estimation discharged intothe lagoon from different sources depending on following formula:

$$\sum Q_{ij} = \sum Q_{ij\ generated} \times R_{ij} \times (1 - r_j H_{ij})$$

ΣQ_{ij} - Total pollution load of substance i discharged into the lagoon from the source j (04 sources)

$\Sigma Q_{ijarising}$ - Total pollution load i generated from the source j

R_{ij}–Pollution load factorfrom the waste sourses discharged into lagoon corresponding to i and j

r_j - Percentage of treated wastewater from source j

H_{ij} - Treatment efficiency corresponding to i and j

Pollution load factor from the waste sourses Rijdischarged into lagoon depends on the type of pollution sources, pollutants, terrain slope, rainfall, distance from the pollution source to the basin and some other mitigation process. However the survey and calculation has been quite costly and complex, we have used the pollution load factor table of Ha Long Bay - Bai Tu Long in Quang Ninh provincedone by JICA, 1998 (table 6) to estimate the amount of pollutant load from coastal sources discharged into the Thi Nai Lagoon. Because theterrain of coastal areas of Thi Nai Lagoon similar to the terrain of Quang Ninh province (Midland-hill and coastal plain areas), theaverage value of thefactorhas been selected corresponding to each substance for each source.

Table 6. Pollution load factor discharged intothe lagoon according to sourse groups

Parameters	Pollution load factor discharged intothe lagoon(R_{ij})			
	Living activities	Industry	Agriculture	Dispersal
COD	0,5 - 0,7/0,60	0,7 - 0,9/0,80	0,2 - 0,5/0,5	0,5 - 0,7/0,60
BOD	0,1 - 0,2/0,15	0,5 - 0,7/0,60	0,1 - 0,2/0,15	0,1 - 0,2/0,15
N-T	0,8 - 0,9/0,85	0,8 - 0,9/0,75	0,6 - 0,8/0,70	0,6 - 0,8/0,70
P-T	0,9 - 1,0/0,95	0,9 - 1,0/0,95	0,8 - 0,9/0,85	0,8 - 0,9/0,85
TSS	0,5 - 0,7/0,60	0,7 - 0,9/0,80	0,2 - 0,5/0,35	0,3 - 0,7/0,50

Source: According to the JICA, 1999;(From 0.5 to 0.7/0.6): The minimum value - largest/average

As for pollutionsources which generated on the lagoon surface and lagoon surburbsuch as coastal aquaculture (industrial shrimp) or the manholes connected to the residential areas, industrial zones directly discharge wastewater into the lagoon... nearly 100% of the waste discharged intothe lagoon.

III. RESULTAND DISCUSSION

1. Currentpollutant load generated in the region and prediction to 2025

These sectors which generate waste in the province include tourism - resident, aquaculture, agriculture (mainly cattle and poultry farming), industry and soil leaching. Pollution load from each source has been calculated in detail below.

1.1. Pollution load from living source

The total population in Thi Nai Lagoon is 172,678 people (in 2013), which occupies for about 11% of the population in Binh Dinh province. Meanwhile the population in the North of Thi Nai lagoon is 20,319 people, in the southwest of lagoon is 147,861 people, in the southeast of lagoon is 3,698 people and in the Con Chim area is 800 people (Le Thi Vinh, 2011).

In the overall planning of social - economic development of Binh Dinh province by 2020, the rate of natural population growth aimed to reduce 0.6 ‰ per year in the period 2006-2010 and keep the stable natural population after 2010. However, in fact, the population here has not been decreased or stable as objectives. It has been increased steadily every year about 0.1 to 0.4% in the period from 2006 to 2010 and lasted until 2012. The population of Binh Dinh province averagely increased 0.25%/year in whole period 2006 - 2012. It has been a very low rate compared to the rate of national population growth (from 1.06 to 1.35%/year in the period 2000-2009 – Vietnamese Statistical Yearbook 2009). Thus, in order to be closer to realistic situation, the population growth rate has been selected about 0.25%/year in average for the period from 2012 to 2025 to predict the population in the researched area to 2025. The results in the researched area will be predicted about 843,500 inhabitants in 2025 (total increase about 3.3% compared with 2012).

Table 7.Current living pollutant load discharged in the area and prediction to 2025

No.	Parameters	Average pollutant load (tons/year)	
		2012	2025
1	COD	5497,20	10,503.94
2	BOD	3,116.84	5,955.59
3	N-T	567.25	1,083.88
4	P-T	160.59	306.85
5	NO_3+NO_2	5.70	10.89
6	NH_4	311.68	595.56
7	PO_4	87.20	166.62
8	TSS	12,294.67	23,492.40

1.2. Pollution load from industrial source

Binh Dinh industry has been differentiated into three distinct subareas since 2000: industrial subarea in Con river downstream, coastal subarea and mountains subarea. The researched area is fully located in Con River downstream subarea where have resources of alluvial deposit, building stone and agriculture, forestry and fisheries. There are 49% of the production facilities, 70.4% industrial employment and 91.5% of the province's industrial production in this subarea. Quy Nhon is the largest industrial center with 67.7% of the province's industrial production (Geography of the provinces and cities in Vietnam, Volume 4).

In 2012, the amount of main industrial products in the area was estimated about 11.9 thousand tons of frozen seafood, 3.3 thousand tons of vegetable oil, more than 27.8 thousand liters of sauce, 765.4 thousand tons milled rice, 55.7 thousand tons of livestock food, 42 thousand tons of sugar, 47.6 million liters of beer, 2.7 thousand tons of paperboard in different kinds ... (Binh Dinh Province Statistic Yearbook 2012).

Expected growth rate of industrial production value of the region has been equal to national industrial growth rate, about 12-13%/year to 2020 and the period from 2021 to 2030 to reach about 11-12%/year. Corresponding to the growth rate of industrial production value in each period, the forecasted industrial waste volume generated in the research area until 2025. According to the master planning after 2020, the industrial parks area in research area will reach about 1766 ha (including Phu Tai, Long My industrial zones and industrial area in Nhon Hoi economic zone) and the total area of the industrial parks which operate in future will be 944ha.

Table 8. Current industrial pollution load in researched area and prediction to 2025

Year	Pollution load (ton/year)							
	COD	BOD	TSS	N-T	P-T	NO_3+NO_2	NH_4	PO_4
2012	9,706.74	3,727.96	3492,87	1192,70	159,93	12,86	451,60	80,13
2020	24,905.4	9,565.1	8962,0	3060,2	410,3	33,0	1158,7	205,6
2025	42,920.8	16,484.1	15444,6	5273,8	707,2	56,9	1996,9	354,3

1.3. Pollution load from farming

Farming in Binh Dinh province has been relatively developing, in comparision with provinces coastal in South centre. In 2012, production value of farming reached approximate 7.8 thousand billion dong with 267.25 thousand of cattles, more than 711 thousand of pigs and about 6.7 millions of poultries. There have been more than 40% of cattles, 30% of pigs and 50% of poultries in researched area. Main farming method was in households or in small farms. With farm scale calculated according to Circular No. 27/2011/TT-BNNPTNT dated 13 April 2011 by Ministry of Agriculture and Rural development, there have been less than 10 farms in researched area. (Quy Nhon 1, An Nhon 4, Tay Son 4 – Binh Dinh Statistical Yearbook 2012).

If the livestock partition structure continuously remained at present, the number of livestock and poultry in the researched area to the year 2020 will be nearly 29 thousand of buffalo, cows and nearly 77 thousand of pigs and more than 1 million of birds. According to Binh Dinh Agriculture development plan period 2016 – 2020, the growth speed of farming is 5%/year. If this speed has been preserving to 2025, the total amount of cattle and poultry will be 36.8 thousand of buffalo, cows, more than 97 thousand of pigs and about 1.4 million of poultries.

Table 9. Current pollution load from farming in the researched area

Parameter	Pollution load from farming (ton/year)			
	Cattle	Pig	Poultry	Total
COD	4508,0	3989,5	2397,2	10894,7
BOD	3733,2	2593,2	684,9	7011,3
N-T	2042,7	797,9	439,1	3279,6
P-T	352,2	499,0	137,0	988,1
NO_3+NO_2	20,5	8,2	4,4	33,0
NH_4	490,2	191,3	105,4	786,8
PO_4	158,4	224,6	41,3	424,3
TSS	21131,3	13963,3		35094,6

Table 10. Predicted pollution load from farming in the researched area by 2025

Parameter	**Pollution load from farming** (ton/year)				**Increase rate compared with 2012 (%)**
	Cattle	**Pig**	**Poultry**	**Total**	
COD	8611,0	7160,7	3682,6	19454,2	78,57
BOD	7131,0	4654,5	1052,2	12837,6	83,10
N-T	3901,8	1432,1	674,5	6008,4	83,20
P-T	672,7	895,6	210,4	1778,7	80,01
NO_3+NO_2	39,1	14,7	6,7	60,5	83,19
NH_4	936,3	343,3	161,9	1441,5	83,20
PO_4	302,6	403,2	63,4	769,2	81,28
TSS	40363,9	25062,5		65426,4	86,43

Thus, by 2025, pollution load discharged from the livestock activities in the region will be increased from 78.57% to 86.43%.

1.4. Pollution load from aquaculture

Aquaculture yield in Binh Dinh province had reached about 8.4 to 9.2 thousand tons per year and production area about 4.6 to 4.7 thousand ha (phase 2010- 2012). In which, shrimp amount was about 6.9 to 7.6 thousand tonnes respectively with shrimp

farming area was decreased from 1,964 ha in 2010 to 2,308 ha in 2012 (Binh Dinh Statistical Yearbook 2012).

Shrimp farming has been thriving in Thi Nai lagoon surroundings in Quy Nhon city and Tuy Phuoc districts. Aquaculture methods in Thi Nai lagoon were mainly intensive shrimp farming and general shrimp farming. Monoculture (intensive and semi-intensive) which mainly farm tiger prawn and prawn in salty preventive embankments in 5 surrounding lagoon communes: Phuoc Thang, Phuoc Hoa, Phuoc Son, Phuoc Thuan and Nhon Hoi district with a total area of approximately 225ha (According to the Pepple's Committee of Communes and Binh Dinh Department of Agriculture and Rural Development 2008).

In crop 1 of 2014, Tuy Phuoc district had 962 ha of shrimp farming with the shrimp production of 664 tons, the average yield was 690kg/ha, including 90 ha of intensive farming and semi-intensive farming (the website of the General Fisheries dated 26 September 2014). It showed that the area of intensive farming and semi-intensive farming surrounding Thi Nai lagoon from 2008 had not been fluctuated. With the intensive shrimp production yields approximately 4 tons/ha/crop, the semi-intensive shrimp production yields about 2.4 tons/ha/crop, the average production about 3.2 tons/ha/crop and the area of semi-intensive and intensive farming in whole year is 225ha, the average shrimp production in Thi Nai lagoon estimated about 720 tons/year.

According to the Binh Dinh Aquaculture Development Plan,shrimp farming area has been stable from2010 onwards. Thus, in 2025, the high yield shrimp farming area in Thi Nai lagoon would not be likely increased in comparision with2020, despite the productivity may be increased with the advancement of technology applications. It is assumed that productivity growth similar in Binh Dinh Aquaculture Development Plan period 2010 – 2020 (about 0.1 tons/ha/year for both forms of intensive farming and semi-intensive), the average shrimp production by 2025 is estimated about 5tons/ha/year, corresponding to shrimpproduction of about 937tons/year.

Table 11. Annual pollution load from shrimp farming in Thi Nai lagoon surrounding and prediction to 2025

No.	Parameter	Year 2012 (ton/year)	Year 2025 (ton/year)	Increase rate compared with year 2012 (%)
1	COD	20,4	26,6	30,39
2	BOD	5,8	7,6	31,03
3	N-T	3,7	4,9	32,43
4	P-T	3,4	4,4	29,41
5	NO_3+NO_2	Inconsiderable	Inconsiderable	-
6	NH_4	0,9	1,2	33,33
7	PO_4	1,5	2,0	33,33

The result in the above table shows that the pollution load from aquaculture in Thi Nai lagoon increased 29 – 33% in comparison with present due to the limitation of farming area and without untrolled farming.

1.5. Pollution load from soil leaching

Con river and Ha Thanh river which originates from Thi Nai lagoon flows into the sea through Quy Nhon watergate . Con River is the largest river in the province, more than 178 km in the length with total basin area approximately 3,067 km^2 and flow velocity about 58.84 m^3/s. The length of Ha Thanh river approximately 58km with total basin area about 580 km^2 and flow velocity about 13.6m^3/s. Both rivers originate from the high mountains, incline from east to west. In the rainy season, flooding and leaching severely happen, whereas depletion in the dry season. The flow velocity in the flood season and dry season is different more than 1,000 times. (Geographic in provinces and cities in Vietnam, Volume 4).

There are two rainy seasons in Binh Dinh province: the abundant rainy season lasts from September to December and the little rainy season lasts from January at the August. There are 03 rainy areas here. The researched area is the little rainy area with precipitation less than 1,800mm located near the middle of the province stretching from coast to the western border which includes the majority of Quy Nhon city, TuyPhuoc, AnNhon, Phu Cat, De Gi district, narrow stripin the north of Tay Son district and half of the south of Vinh Thanh district. The average rainy day per month is highest in October and November and lowest in February and March. The average rainy day per year from79 days(Vinh Kim station inVinh Thanh district) to124 days (Quy Nhon station), the average rainy day per year about 100 days in whole province. Add up specialized land and living land into residential land, forestry land considered belong to forest and grasslands, the remaining is vacant land.

Table 12. Land use status in the researched area

No.	District/ City	Agricultural land	Forestry land	Living land	Vacant land	Total land area
1	Quy Nhơn	2,882	10,316	5,344	10,011	28,553
2	An Nhơn	11,158	6,467	3,508	3,131	24,264
3	Tuy Phước	9,817	2,378	3,876	5642	21713
4	½ Vĩnh Thạnh	5,012	22,992.5	693.5	7,427.5	36,126
5	½ Tây Sơn	8,254.5	17,339.5	3,568.5	5,485.5	34,648
6	½ Phù Cát	9,840	12,179	2,488	9,517.5	34,024.5
7	**Total**	**46,963.5**	**71,672**	**19,478**	**41,214.5**	**179,328**

Sources*: Binh Dinh Statistical Yearbook 2012*

The documents related to land use planning in the region that we have collected include Binh Dinh province and Tuy Phuoc district land use planning to 2020. The land use planning to 2020 of 4 other districts and Quy Nhon city have not been implemented. Therefore, except Tuy Phuoc district, the land use structure of the remaining districts and city to 2020 and 2025 will be followed to the average rate of increase and decrease of each type of land use in Binh Dinh province.

Currently, unused land occupies15.2% of the province land, in which mountain mainly occupies 12.7% , unused flat land occupied1%, rocky mountain without plant occupies 0.7%. It is expected that unused land about1. 19% of the total area of Binh Dinh province in 2020.Thus, the land use structure hardly big changed in the next period.Agricultural and unused land may be slightly decreased due to changing use purpose for specialized land and building land.The forest land is hardly increased. Basically, in 2025,the land use structure in Binh Dinh province will not be major changed in comparision with 2020.

Table 13. Current pollution load from soil leaching

Parameter		Pollution load from soil leaching (ton/year)			
	Forestry land	Agricultural land	Vacant land	Living land	Total
COD	1,433.4	1,315.0	1,072	818	4,638.1
BOD	1,003.4	845.3	659	740	3,248.3
N - T	716.7	1,690.7	1,319	390	4,115.8
P - T	286.7	375.7	247	234	1,143.4
TSS	14,334.4	117,408.8	103,036	3,896	238,675.0
COD	1,433.4	1,315.0	1,072	818	4,638.1

Table 14. Predicted pollution load from soil leaching by 2025

Parameter	Pollution from soil leaching (ton/year)				Decrease rate compared with 2012 (%)
	Agricultural land	Forestry land	Living land	Total	
Area (ha)	32,565.6	87,965.2	17216,7	137,747.5	
COD	1,759.3	911.8	723.1	3,394.2	26.82
BOD	1,231.5	586.2	654.2	2,471.9	23.90
N - T	879.7	1,172.4	344.3	2,396.3	41.78
P - T	351.9	260.5	206.6	819.0	28.37
TSS	17,593.0	81,414.0	3,443.3	102,450.4	57.08

Compared with 2012, agricultural land in the researched area has been reduced about 30.66%, forest land has been increased 22.73%, living land increased by 47.93%, vacant land should be narrowed lead to the pollution load from soil leaching decreased from 26.82% to 57.08%.

1.6. Total pollution load in Binh Dinh province

Pollution load in whole province calculated by summarizing all discharged sources (Table 15 and Table 16).

Table 15. Total pollution load in the researched area

Parameter	Total pollution load (ton/year)					Total
	Living	Industry	Farming	Aquaculture	Soil leaching	
COD	5.497,20	9706,74	10894,7	20,4	4638,1	30.757,16
BOD	3.116,84	3727,96	7011,3	5,8	3248,3	17.110,25
N-T	567,25	1192,7	3279,6	3,7	4115,8	9.159,13
P-T	160,59	159,93	988,1	3,4	1143,4	2.455,48
NO_3+NO_2	5,70	12,86	33,0	-		51,60
NH_4	311,68	451,6	786,8	0,9		1.551,00
PO_4	87,20	80,13	424,3	1,5		593,16
TSS	12.294,67	3492,87	35094,6		238675,0	289.557,18
Rate (%)						5.497,20
COD	17,87	31,56	35,42	0,07	15,08	100.00
BOD	18,22	21,79	40,98	0,03	18,98	100.00
N-T	6,19	13,02	35,81	0,04	44,94	100.00
P-T	6,54	6,51	40,24	0,14	46,57	100.00
NO_3+NO_2	11,04	24,92	64,04		-	100.00
NH_4	20,10	29,12	50,73	0,06	-	100.00
PO_4	14,70	13,51	71,54	0,25	-	100.00
TSS	4,25	1,21	12,12	-	82,43	100.00

Note: *(-) Inconsiderable or incalculated*

The data in Table 15 indicate that annual pollution load in the researched area approximate 30.7 thousand tons of COD; 17.1 thousand tons of BOD; 9.1 thousand tons of N-T, 2.4 thousand tons of P-T and 289 thousand tons of TSS. Among the discharge sources from human activities, the discharge sources from livestock has been the main pollution load discharge into the Thi Nai lagoon, followed by the discharge source from industrial and living activities, the discharge source from aquaculture has taken very little waste.

Table 16. Predicted pollution load in Binh Dinh province to 2025

Parameter	Pollution load (ton/year)					Total
	Living	Industry	Farming	Aquaculture	Soil leaching	
COD	10.503,94	42.920,8	19.454,2	26,6	3.394,2	76.299,83
BOD	5.955,59	16.484,1	12.837,6	7,6	2.471,9	37.756,80
N-T	1.083,88	5.273,8	6.008,4	4,9	2.396,3	14.767,38
P-T	306,85	707.2	1.778,7	4,4	819,0	3.616,18
NO_3+NO_2	10,89	56.9	60,5	-		128,32
NH_4	595,56	1.996,9	1.441,5	1,2		4.035,15
PO_4	166,62	354.3	769,2	2,00		1.292,12
TSS	23.492,40	15.444,6	65.426,4	0	102.450,4	206.813,78
Rate (%)	Rate of pollution load from discharged sources (%)					
COD	13,77	56,25	25,50	0,03	4,45	100,00
BOD	15,77	43,66	34,00	0,02	6,55	100,00
N-T	7,34	35,71	40,69	0,03	16,23	100,00
P-T	8,49	19,56	49,19	0,12	22,65	100,00
NO_3+NO_2	8,49	44,34	47,17	-	-	100,00
NH_4	14,76	49,49	35,72	0,03	-	100,00
PO_4	12,90	27,42	59,53	0,15	-	100,00
TSS	11,36	7,47	31,64	-	49,54	100,00

It is expected that in 2025, total pollution load in the researched area occupies about 76.2 thousand tons of COD, more than 37.7 thousand tons of BOD; 14.7 thousand tons of N-T (in which about 128.32 tons of NO_3^+, NO_2^- and more than 4 thousand tons of NH_4^+); more than 3.6 thousand tons of P-T (in which about 1.3 thousand tons of PO_4^{3-}) and more than 206 thousand tons of TSS (Table 16).

The comparison between discharge sources by 2025 has showed that the pollution load from industrial has been the largest, followed by the pollution load from livestock, living and soil leaching. The pollution load from aquaculture has been the smallest in comparison with others.

Compared to the pollution load in 2012, the pollution load in 2025 will be increased 1.4 times to 2.6 times,

in which the concentration of ammonium will be increased highest (2.6 times) due to the increase of waste from the industrial and livestock activities. In particular, the concentration of TSS will be decreased by 28% compared to present due to the main source of TSS has been still soil leaching. Because of land use change in 2025, cultivated soil area should reduce, the concentration of TSS from soil leaching will be decreased.

2. Pollution load discharged into Thi Nai lagoon

Binh Dinh province has not really pay attention to the wastewater treatment issue (the percentage of treated waste water is low: about 20% of industrial waste water, 10% of livestock waste water). Additionally, the sewerage system has not been completed (only about 10% of the households installed sewage system). Besides, the terrain sloped from west to east, so the pollution load from soil leaching into the lagoon has been high (from 51% - 90% of all discharge sources, excluding BOD only about 18%). Thus, the annual pollutants in Thi Nai lagoon as follow: About 17.8 thousand tons of COD; 3.8 thousand tons of BOD; more than 6.4 thousand tons of NT (including 36 tons of NO_2^- and NO_3^- and more than 01 thousand tons of NH_4^+); 2,016 tons of P-T (nearly 515 tons of PO_4^{3-}) and nearly 140 thousand tons of suspended solids, Table 17.

The comparison between the pollution load from discharge sources has showed that:

Among the pollution load discharged into the Thi Nai lagoon, BOD occupies for 21.79%, COD occupies for 57.77%, N-T and P-T occupies from 68.50 to 86.19% and TSS occupies for 47.83%.

As for organic waste, pollution load from industrial sources has been major (about 36 – 49%). The main products of industry which generate organic waste including frozen shrimp, rice milling, beer. Besides, there has much organic waste from livestock sources, occupies for 26% -29%, followed by the pollution load from living source (11-18%) and soil leaching (12-15%).

As for N and P compounds, pollution load from soil leaching has been major (about 34 – 39%), followed by the pollution load from industrial and living source. The pollution load from aquaculture has been minor source. However, the source should be concerned because it is direct source.

Table 17. Current pollution load discharged into Thi Nai lagoon

Parameter	**Pollution load from sources** (ton/year)					**Total (ton/year)**	
	Living	Industry	Farming	Aquaculture	Soil leaching	Discharged	Generated
COD	3.199,37	6.522,9	5284,0	20,4	2,783	17.809,47	30.827,27
BOD	444,15	1.878,9	999,1	5,8	487	3.815,21	17.511,05
N-T	472,52	867,7	2249,8	3,7	2,881	6.474,84	9.452,78
P-T	151,04	148,9	831,5	3,4	972	2.106,76	2.444,33
NO_3+NO_2	4,75	9,4	22,7	-		36,815	54,52
NH_4	259,63	328,5	539,8	0,9		1.128,79	1.621,49
PO_4	82,01	74,6	357,1	1,5		515,18	591,94
TSS	6.860,43	2.347,2	11423,3		119,338	139.968,43	292.652,46
Rate (%)	**Rate of discharged sources (%)**						**Discharged/ Generated**
COD	17,96	36,63	29,67	0,11	15,63	100,00	57,77
BOD	11,64	49,25	26,19	0,15	12,77	100,00	21,79
N-T	7,30	13,40	34,75	0,06	44,50	100,00	68,50
P-T	7,17	7,07	39,47	0,16	46,13	100,00	86,19
NO_3+NO_2	12,89	25,53	61,57	-	-	100,00	67,53
NH_4	23,00	29,10	47,82	0,08	-	100,00	69,61
PO_4	15,92	14,48	69,31	0,29	-	100,00	87,03
TSS	4,90	1,68	8,16	0,00	85,26	100,00	47,83

Note*: (-) Inconsiderable*

Table 18. Total pollution load discharged into Thi Nai lagoon by 2025

Parameter	**Pollution load from discharged sources** (ton/year)					**Total (ton/year)**	
	Living	Industry	Farming	Aquaculture	Soil leaching	Discharged	Generated
COD	4.941,1	6.609,8	4.182,7	26,6	2037	17.796,7	76.299,8
BOD	636,1	964,3	462,2	7,6	371	2.440,9	37.756,8
N-T	755,5	2.076,6	2.208,1	4,9	1677	6.722,5	14.767,4
P-T	260,0	512,3	1.081,0	4,4	696	2.553,9	3.616,2
NO_3+NO_2	7,6	22,4	22,2	-		52,2	128,3

Parameter	Pollution load from discharged sources (ton/year)					Total (ton/year)	
	Living	Industry	Farming	Aquaculture	Soil leaching	Discharged	Generated
NH_4	415,1	786,3	529,7	1,2		1.732,4	4.035,1
PO_4	141,2	256,6	467,5	2		867,3	1.292,1
TSS	9.274,8	1.791,6	2.232,7	0	5.1225	64.524,3	206.813,8
Rate (%)	**Rate of discharged sources**						**Discharged/ Generated**
COD	27,76	37,14	23,50	0,15	11,44	100,00	23,32
BOD	26,06	39,51	18,93	0,31	15,19	100,00	6,46
N-T	11,24	30,89	32,85	0,07	24,95	100,00	45,52
P-T	10,18	20,06	42,33	0,17	27,26	100,00	70,62
NO_3+NO_2	14,53	42,89	42,59		-	100,01	40,71
NH_4	23,96	45,39	30,58	0,07	-	100,00	42,93
PO_4	16,28	29,59	53,90	0,23	-	100,00	67,12
TSS	14,37	2,78	3,46	0,00	79,39	100,00	31,20

Note*: (-) Inconsiderable.*

Prediction results in 2025 shows that the pollution load which discharged into Thi Nai lagoon about 17.8 thousand tons of COD; 2.4 thousand tons of BOD; 6.7 thousand tons of NT (including about 52.2 tons of soluble nitrogen NO_2^- and NO_3^- and nearly 1.7 thousand tons of NH_4^+); 2.55 thousand ton of P-T (about 867 tons of PO_4^{3-}) and 64.5 thousand tons of suspended solid, Table18.

The comparison between the pollution load from discharge sources into Thi Nai lagoon shows that:
As for organic pollution load, the industrial sources is major, followed by living, farming and soil leaching. As for nutrients, the farming source is major, followed by industrial, living and soil leaching source. As for TSS, the soil leaching source is major, followed by living source, other sources are minor.

In general, in comparison with the pollution load generation, pollution load discharged into the Thi Nai lagoon occupies about 6 -23% for organic compounds, from 40-70% for the nutrients, and about 31.2% for TSS. It is remarkable that phosphate occupies 67.12%. This shows that the necessity of improving the phosphate treatment efficiency.

IV. CONCLUSION

The annual pollution load in Binh Dinh province approximate 30.7 thousand tons of COD; 17.1 thousand tons of BOD; 9.1 thousand tons of N-T, 2.4 thousand tons of P-T and 289 thousand tons of TSS. Among the discharge sources from human activities, the discharge sources from farming has been the main pollution load discharge into the Thi Nai lagoon, followed by the discharge source from industrial and living activities, the discharge source from aquaculture has taken very little waste. It is expected that in 2025, total pollution load in the researched area occupies about 76.2 thousand tons of COD, more than 37.7 thousand tons of BOD; 14.7 thousand tons of N-T (in which about 128.32 tons of NO_3^+, NO_2^- and more than 4 thousand tons of NH_4^+); more than 3.6 thousand tons of P-T (in which about 1.3 thousand tons of PO_4^{3-}) and more than 206 thousand tons of TSS.

The annual pollutants discharged into Thi Nai lagoon as follow: About 17.8 thousand tons of COD; 3.8 thousand tons of BOD; more than 6.4 thousand tons of NT (including 36 tons of NO_2^- and NO_3^- and more than 01 thousand tons of NH_4^+); 2,016 tons of P-T (nearly 515 tons of PO_4^{3-}) and nearly 140 thousand tons of suspended solids. Prediction results in 2025 shows that the pollution load which discharged into Thi Nai lagoon about 17.8 thousand tons of COD; 2.4 thousand tons of BOD; 6.7 thousand tons of NT (including about 52.2 tons of soluble nitrogen NO_2^- and NO_3^- and nearly 1.7 thousand tons of NH_4^+); 2.55 thousand ton of P-T (about 867 tons of PO_4^{3-}) and 64.5 thousand tons of suspended solid.

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