Studies of the Principles of Environmental Planning for the Beijing-Tianjin-Bohai Bay Area

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Introduction

With the solution of local pollution problems, the academic community of the world has paid ever increasing attention to regional characteristics of environmental pollution and global deterioration of environmental quality.

The Beijing-Tianjin-Bohai Bay area (BTB) in northern China constitutes a typical suite of natural environmental patterns involving mountains, plains and a coastal bay, covering a land area of approximately 34000 km^2 and an offshore area of 16000 km^2. This area has a population of 19 million with the capital of China located there. It is highly developed in economy and culture. However, environmental pollution and ecosystem disturbance are becoming increasingly conspicuous with the rapid development of industrialization and urbanization.

Early in 1972 research on environmental pollution was initiated in some localities of this area. But our knowledge of what affects the regional environmemt is still very inadequate. Previous emphasis was placed on the source region of pollution as well as on pollutions caused by immediate human activities. It failed to look into the effects of subsequent diffusion of the pollutants on the entire regional environment. Meanwhile, the subject has not been adequately dealt with from a historical point of view and the interrelations between natural and human factors have been neglected. Therefore, many challenging problems remain to be solved. To provide a critical scientific background for the planning of land utilization and environmental management one must address the following questions:

(1) the relationship between the two metropolitan areas —— Beijing and Tianjin with respect to pollution influence;

(2) the relationship among urban districts, suburbs, distant suburbs and coastal bay areas with respect to their environmental capacities;

(3) the relationship between natural and human factors with respect to the source of pollutants, their migration and environmental effects and the occurrence of various environmental problems and their influences; and

(4) the interrelations among self-purification, capacity and environmental quality within the entire area of interest.

Obviously, to address these questions requires a comprehensive study on the regional environments on a large time-and-splace scale. Two major viewpoints are presented as follows:

(1) Regional overview of environmental planning

Together with their surrounding regions and offshore area, the two big cities, Beijing and Tianjin, constitute a society-economy-nature interconnected region. The

mutual adjustment of metropolitan ecosystem-farm land ecosystem-mountain and ocean ecosystem has proven to be an effective approach to improving the regional environmental quality of the BTB area.

(2) Synthetic overview of environmental policies

The differentiated characteristics of natural environmental structure of the BTB area have constrained the differences in environmental load capacity. Countermeasures such as separated exploitation on the one area-after-another basis, making use of natural environmental purification and synthetic prevention of regional pollution have been taken to protect the regional environments of the area.

China is a developing country. The synthetic prevention on a regional environment scale is considered a fundamental principle of environmental planning and management policy.

Fundamental Environmental Characteristics of the BTB Area

Obvious interrelationship among various factors affecting the natural environment pattern in the BTB area, as well as their close interactions with human effects, are well demonstrated. So the BTB area is a typical environmental region as viewed from the conception of human environment. The regional environmental characters can be outlined as follows:

The step-wise natural environment pattern

As a result of the action of geological agents, the area has developed into a mountain-plain-bay step-wise landscape, with the rivers flowing southeastwards into the Bohai Bay. Therefore, an apparent zonal distribution of environmental units is noticed. Solar radiation also varies in a step-wise manner in going from the mountains through the plains to the bay area. Annual mean temperature increases in the same direction, and a zonal pattern can be noticed for the rainfall from the mountainous area through the foothill zone to the plain. Additionally, the process of transport of surface materials shows a leaching-transition-accumulation trend toward the sea, paralleled by a gradational change from brown soil through damp soil to coastal saline soil, as well as by a zonal pattern of vegetation. On account of the various geochemical agents, such a general migration pattern as leaching-transition-accumulation can be recognized for all surface materials in this area. Such regional geochemical differentiation plays a key role in understanding the functions of various environmental factors. For example, either the load capacity of soil or the transporting power of the atmosphere and running water or the purification capacity of vegetation varies in a corresponding step-wise manner.

The ring structure of human activities

As is well known, most environmental problems in modern time are related to urbanization. The two big cities, Beijing and Tianjin, together with the connecting areas where many constructions, industries and traffic networks are distributed, constitute a dumb bell-shaped urbanized ecosystem surrounded by a farm ecosystem, with scattered patches of local industry, on the plain as the first-order periphery, which is in turn encircled by the second-order periphery of mountainous and oceanic ecosystems. The urbanized environment is maintained and regulated by the peripheral environments

which are at the same time influenced by the former. Thus, the various rings are mutually affected from an environmental point of view.

The semi-open migration system of environmental materials

Various geochemical units and ecosystems are connected by the low atmosphere, surface water system and human activities. In the BTB area the SE wind is dominating during summer-autumn seasons due to the influence of the Pacific subtropic high pressure, while the NW wind is prevailing in winter and spring as a result of Siberia and Nei Mongol high pressure. The drainage system in this area belongs to the Haihe drainage system, with all the major rivers (Chaobai River, Ji-Canal, North-Canal, Yongding River and Daqing River) flowing into the Bohai Bay. On the plain an irrigation network has been constructed. Mass and energy transfer in the area is significantly intensified as a result of human activity. A partly open system has been established between the mountains and the coastal bay with respect to material migration.

Generally speaking, the answers to most of the environmental problems encountered in the BTB area can be found in the light of the fundamental environmental characters of the area, i. e., the step-wise natural environment pattern, the ring structure of human activities and the partly open system relative to material migration.

Geochemical Environment Types in the BTB Area

Governed by the unique step-wise natural pattern, three geochemical environmental units can be distinguished with respect to the migration and deposition of surface materials in the BTB area.

Some characteristic element assemblages can be recognized in the loose surface sediments as a result of mechanical transport, chemical leaching and biological activity under the action of supergenic geochemical agents, reflecting the equilibrium status of material exchanges on the interfaces among various environmental facies such as water, atmosphere, soil and organism. As a result of chemical differentiation, these characteristic element assemblages are the basis for the division of geochemical environments.

More than 20 types of regolith are recognized in the BTB area. In order to investigate the geochemistry of these regoliths, the ionic proportions of the seven components (pH, Na^+, Ca^{2+}, Mn^{2+}, Fe^{3+}, F^- and Cl^-) are examined.

The ion equivalent ratios of Na^+ / Cl^-, Ca^{2+} / F^-, Mn^{2+} / Fe^{3+} and Cl^- / F^-, in conjunction of pH values, provide the grounds for the division of the three environmental units into twelve types of geochemical environment in the BTB area, the ten types of which are most typical (Table 1, Fig. 1), as can be seen from Table 1 and Fig. 1.

The Na^+ / Cl^- and / or Cl^- / F^- ratios can probably be used as the indices for regional geochemical equilibrium in the BTB area. From the typical leaching environment A_2, through the transitional environment B_2 to the accumulating environment C_2 ($A_2 \rightarrow B_2 \rightarrow C_2$), Na^+ / Cl^- tends to decrease from $n \cdot 10^2$ to $n \cdot 10^1$ to $n \cdot 10^0$, whereas Cl^- / F^- tends to increase from $n \cdot 10^{-2}$ to $n \cdot 10^0$ to $n \cdot 10^1$. The characteristic step-wise equilibrium reflects the typomorphic features of the three environmental

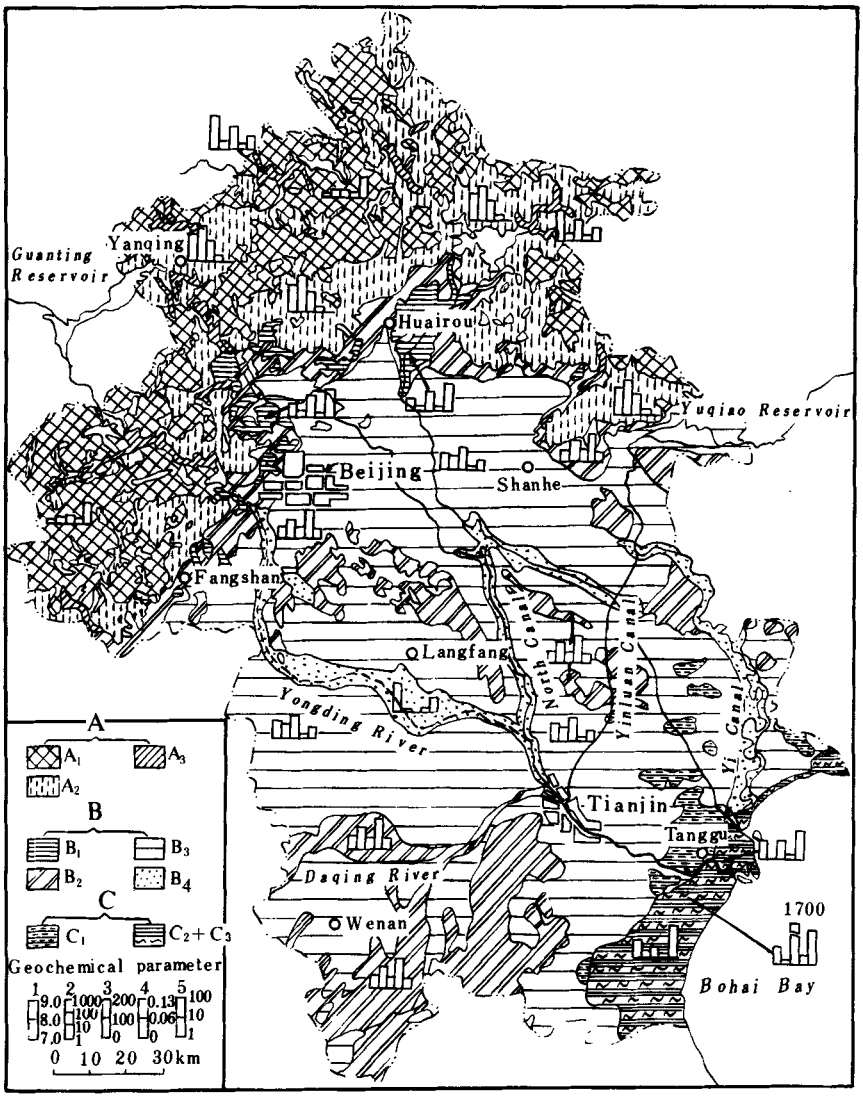


Fig.1. The division of geochemical environment units in the BTB area.

A. Geochemical environment unit consisting of mountain-leaching regions : A_1 quasi-leaching ; A_2 leaching ; A_3 leaching-transitional ;

B. Geochemical environment unit consisting of alluvial-pluvial plains and transitional regions : B_1 quasi-transitional ; B_2 reducing-transitional ; B_3 transitional ; B_4 sandhill ;

C. Geochemical environment unit consisting of bay, coast and accumulating regions : C_1 strong accumulating ; $C_{2,3}$ accumulating and bio-accumulating.

Geochemical parameters : 1. pH ; 2. Na^+/Cl^- ; 3. Ca^{2+}/F^- ; 4. Mn^{2+}/Fe^{3+} ; 5. Cl^-/F^-.

units. However, the differentiational characteristics of the ion group are notable between different environment types in every geochemical environment unit. For example, in the leaching environment unit both A_1 and A_3 are characterized by accumulation ; in the transitional environment unit B_1 and B_3 show a relative accumulation tendency as well. Thus, as viewed from the regional environments, the equilibrium series of Na^+/Cl^- and /or Cl^-/F^- reflect the order of leaching and accumulation for different environment types (Table 2).

Ca^{2+}/F^- and Mn^{2+}/Fe^{3+} ratios can be regarded as the indices for regional

Table 1. Characteristics of geochemical environment types in the BTB area

Mor phologic structure unit	Geochemical unit	Geochemical environment type	Regolith type	Geochemical parameter				
				pH	Na^+/Cl^-	Ca^{2+}/F^-	Mn^{2+}/Fe^{3+}	Cl^-/F^-
Mountainous area	Leaching area A	Quasi-leaching A_1	Clay soil in middle-mountain	7.28	5.4	47	0.021	17
		Leaching A_2	Sandy soil in low-mountain and basin	8.51	772	117	0.022	0.1
		Leaching-accumulating A_3	Silp in flood land	8.85	7.3	125	0.024	7.9
Plain area	Transitional area B	Quasi-transitional B_1	Sandy soil in foothill	7.80	3.6	120	0.021	38
		Reduction-transitional B_2	Clay, Loess and Saline soil in foothill and plain	7.83	61	77	0.115	5.1
		Transitional B_3	Sandy soil in plain and silp in low-lying land	8.07	27	140	0.020	81
		Sandbank B_4	Sandbank	8.70	1.4	8.2	0.019	3.4
Bay-coastal area	Accumulating area C	Strongly accumulating C_1	Silp in flood land and low-lying land	8.10	0.9	70	0.022	81
		Accumulating C_2	Sediment in bay	8.20	1.2	105	0.020	41
		Bio-accumulating C_3	Silp in seabeach	8.00	1.6	1700	0.029	80

Table 2. The equilibrium series of Na^+/Cl^- and Cl^-/F^- reflecting the order of leaching and accumulation for different environment types

Environment type	A_2	B_2	B_3	A_3	A_1	B_1	C_3	C_2	C_1
Na^+/Cl^-	772	61	27	7.3	5.4	3.6	1.6	1.2	0.9
Cl^-/F^-	0.1	5.1	5.7	7.9	17	38	80	41	81
Environmental character	leaching → accumulation								

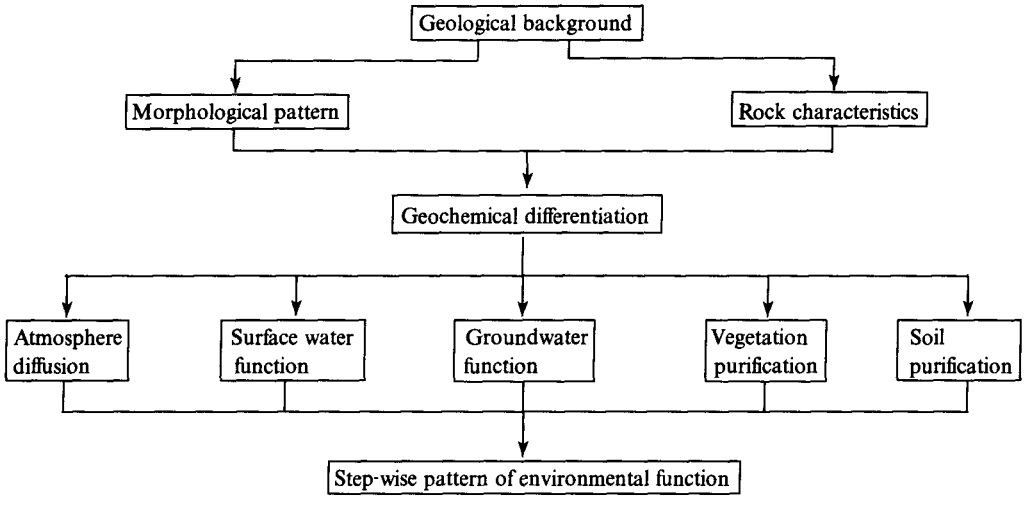
geochemical equilibrium in the BTB area. Ca^{2+}/F^- indicates local Ca enrichment while Mn^{2+}/Fe^{3+} mirrors local oxidation-reduction conditions. For example, the type-B_2 environment shows a reduction character, but the type-C_3 environment is notably influenced by Ca-enrichment by living organisms. Ca-differentiation is also observed in the other environment types.

In the different environment types different ions are leached and accumulated to different extents. So there exist some differences in equilibrium relations between acids and alkalies. However, when the area is transformed into an accumulation environment

from a leaching environment, regional equilibrium would be reached, which can reflect a relatively alkaline environment.

Environmental Purification Capacity and Division of Protection Regions in the BTB Area

A regional natural environment, as a unified regime, would evolve in accordance with the following processes:



From a viewpoint of environmental function, the BTB area can be divided into three major regions (mountains, plains and coastal bay) and fourteen types of environment (Fig. 2) in the light of comparative studies (Table 3) based on morphologic patterns and surface environment types.

The mountainous environment regions (I)

I_1: Mountain quasi-leaching-waterhead-brown soil-coniferous broadleaf forest environment region

Distributed in parts of the windward slopes of the middle mountains, this type of environment is characterized by a weak acid-resisting capacity and more leachable soil. Natural vegetation has a strong purification ability relative to SO_2, a favourable factor preventing air pollution.

Special efforts should be made to protect this environment region.

I_2: Mountain leaching-waterhead-brown soil-broadleaf forest environment region

It is distributed in low mountainous areas along the upper reaches of water-storage districts. Metal and other ions are readily soluble and carried away. Highly acid-resistent, the vegetation has a strong purification ability against air pollution. This environmental pattern is characteristically stable, and special attention should be paid to the protection of water resources.

I_3: Mountain leaching-waterhead-brown-damp soil-grass and cultivated land environment region

Located on the margins of the terrace hillside, fan-slope land and water-storage districts. Metal and other ions are readily soluble. The region is of strong acid-resistence. Crops and grass may take part in purifying harmful gases. For such a

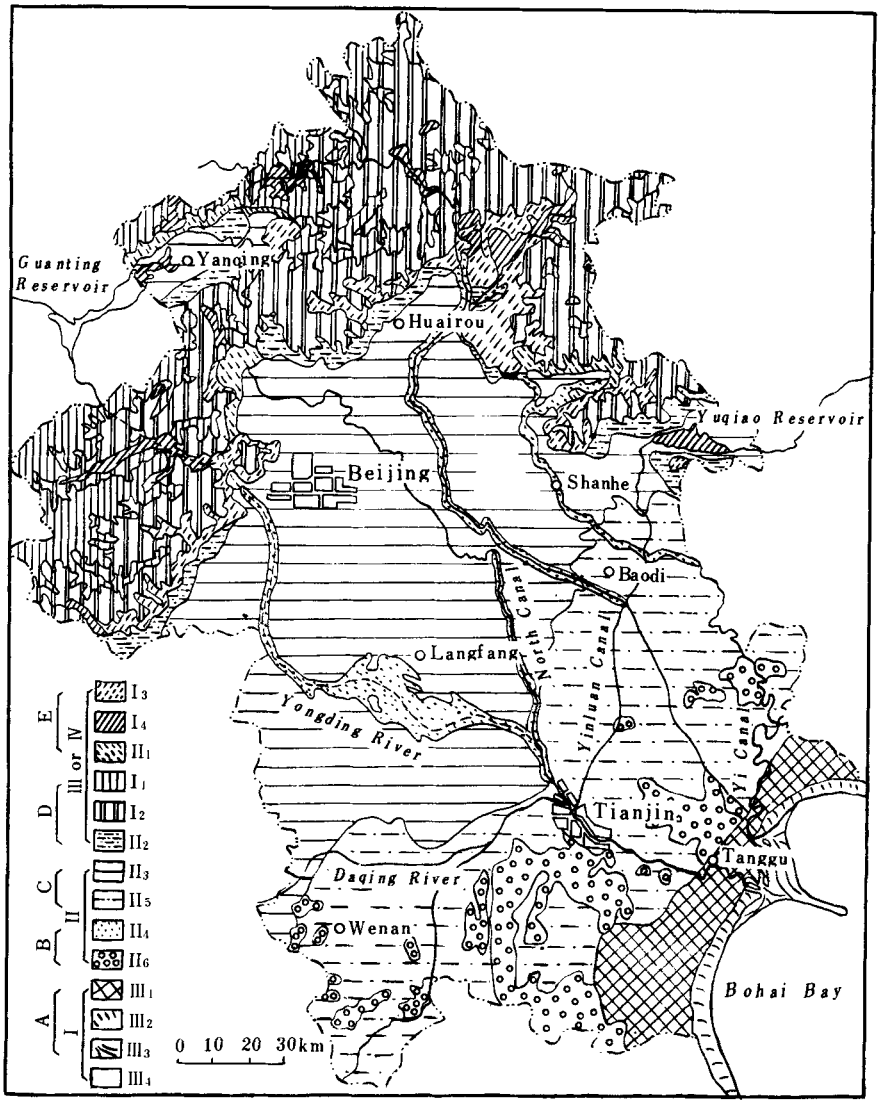


Fig.2. The division of environmental functions in the BTB area. (For explanations see Table 4)
A. Selective utilization area ; B. reform-utilization area ; C . controlled exploitation area ; D. second-order protection area ; E . first-order protection area .
I. Coast-bay environment ; II. plain environment ; III. mountain environment ; IV. plain environment.

relatively stable environment region, great efforts should be devoted to preventing water and soil erosion, and pollution should be brought under strict control.

I_4 : Mountain leaching-accumulation-lake reservoir-sandbank-grass and aquatic vegetation environment region

Located in river terraces and lakes and reservoirs in mountainous areas.

Some metals may be accumulated to a certain extent in this region, but the vegetation still possesses a certain purification ability. Because this environment region is of groundwater storage, it is recommended to devote great efforts to protecting such an environment region.

Plain environment regions (II)

II_1 : Foothill quasi-transition-groundwater recharge-brown-damp soil-grass and

Table 3. Comparison of environmental characteristics between the various environment units in the BTB area

Morphologic pattern	Surface environment type		Functional division of surface waters		Environmental function of groundwaters		Environmental function of atmosphere	Environmental function of soil purification		Purification power of vegetation	Geochemical environment type		Division of environmental functions	
Mountainous unit	Mountain	Middle	Waterhead		Supported region		Strong diffusion	Low capacity		High	Leaching	Quasi-leaching and leaching	Mountainous region	I_1
		Low						Mod. capacity						II_2
	Foothill pluvial-alluvial fan and hillfront flood-alluvial inclined plain	Fan-slope						Higher capacity		Mod. and / or low				I_3
		Hillside terrace										Leaching-accumulating		I_4
		River terrace												
		Lake-reservoir water												
Pluvial-alluvial plain unit		Fan-slope	Dissipation region	Hill-front plain	Exploitation region	Major supplies	Mod. diffusion				Transitional	Quasi-transitional	Plain region	II_1
		Hillside terrace												II_2
		Inclined plain										Transitional		II_3
		River terrace						Damp soil	High capacity			Sand dune		II_4
		Flood plain												
		Sandy land												II_3
City district included	City	Beijing suburb							Mod. capacity			Transitional		
		Beijing urban					Strong diffusion							II_5
		Tianjin suburb		Coastal plain		Deep supplies								
		Tianjin urban						Saline soil	Lower capacity	Low				II_4
Coastal bay unit	Coastal Plain	Slightly inclined plain					Moderate diffusion				Accumulating	Strongly accumulating	Coastal bay region	III_1
		Damp lowland				Saline water			Low capacity					
		Reed pond								Extremely low				III_2
		Lake-reservoir water										Accumulation and organic accumulation		
		Saline land												III_3
	Bohai Bay	River-mouth waste-discharge area	Residence region				Weak diffusion							III_4
		Intertidal zone												
		Sea water												

cultivated land environment region

Distributed in sandy-soil areas around foothill, fan-shaped slopes where downward seeping of groundwaters is indicated. The metallic ions show a transitional behavior from leaching to accumulation. Vegetation may act, to some extent, as a purifying agent. This type of regions is environmentally sensitive. Discharge of waste materials, especially those which can readily soak down to the ground, should be prohibited so as to avoid harmful effects on groundwater resources as well as on other plain environments.

II_2: Foothill reducing-transition-groundwater recharge-brown-damp soil-grass-cultivated land environment region

Located in clay soil terrains in foothill areas. The soil layers are less permeable. Other features are similar to those of II_1. This is also a sensitive environment region.

II_3: Alluvial plain-water consuming-damp soil-cultivated land environment region

Located in declining alluvial-pluvial sandy soil terranes. The migration-accumulation of surface materials is of transitional nature and cultivated vegetation may purify the air to some extent. Human activity is intensive, urbanization is highly developed, groundwater is consumed at a significant rate, and large amounts of gas and water pollutants are discharged. Although this type of environment regions can accommodate significant amounts of acid, heavy metals and organic matter, protection measures should still be taken. Limited exploitation is recommended.

II_4: Alluvial-pluvial plain-sand dune-desert environment region

Distributed in river terraces and flooded regions, with scarce vegetation. This type of environment regions is vulnerable, and reclamation programs are urgently required.

II_5: Central plain-transitional-water-deficient-damp soil-cultivated vegetation environment region

Located in slightly inclined alluvial-pluvial plains. Surface material migration is of transitional type with a tendency of increasing accumulation. Signs of salinization begin to appear. Groundwaters at shallow depths contain high amounts of mineral material. Considerable amounts of acid, metal and organic matter can be accommodated. Also, urbanization is as highly developed as II_3. Exploitation should be based on careful environmental studies.

II_6: Water-deficient-salinization-brown soil-saline meadow environment region

Distributed in lowland terrains adjacent to II_5, and characterized by salt accumulation and deficiency of fresh water. Purification of air pollutants by vegetation is limited. Reclamation measures should be taken and exploitation must be based on careful environmental evaluation.

Coastal bay environment regions (III)

III_1: Brackish water-saline soil-saline meadow-wasteland-offshore strong accumulation environment region

Located in the narrow terrains of coastal lowland plain, with widespread saline and reed ponds. Terrestrial material is highly accumulated. Salinization is extensive. Vegetation is scarce. Pollutants carried by surface runoff are accumulated in such an environment region. Selective exploitation is recommended.

III_2: Brackish water-saline water-strong estuary accumulation environment region

Located in the Haihe River mouth where heavy metals, mud and sand are accumulated. Heavy metal pollutants may be purified to a certain extent. Harmful effects of pollutants on aquatic living organisms should be taken into serious consideration. Exploitations are recommended to be carried out on the basis of careful planning.

III_3 : Intertidal-shallow sea-organic accumulation-seabeach environment region

Located in the intertidal zone and shallow sea area along the coastal bay. Similar to III_2 with respect to environmental characters. Exploitation has been based on careful planning.

III_4 : The Bohai Bay area

Characterized by abundant oceanic living organisms and oil resources as well as a great environmental capacity. Attention should be paid to avoiding excessive capture of fish and shrimp and coastal pollution due to oil exploitation.

Different environmental protection and exploitation strategies are suggested (Table 4), as illustrated in Fig2, for the various environmental units based on comprehensive studies of the environmental functions for the entire BTB area.

Areas which should be brought under first-order protection : I_3 , I_4 and II_1 ;

Areas under second-order protection : I_1 , I_2 and II_2 ;

Areas under limited exploitation : II_3 and II_5 ;

Areas under reclamation-exploitation : II_4 and II_6 ;

Areas under selective exploitation : III_1 , III_2 , III_3 and III_4 .

Principles of Regional Environmental Planning for the BTB Area

Principles of regional environment management

The principles of regional environment management which should be considered together with the overal plan for regional environment protection and improvement and economic exploitation of the BTB area are : the step-wise pattern of natural environment function must be followed ; the dumb bell-shaped structure surrounding the cities must be preserved ; and equilibrium between the ring structures in the area as a whole has to be maintained.

(1) Different environment managements should be adopted in different areas according to their natural environment characters. The distribution of areas under protection, restricted exploitation, reclamation-exploitation and selective exploitation, as mentioned in the previous sections, should also follow a step-wise pattern, although some overlap is permitted. The general strategy of protecting the upper reaches of the mountainous areas and reclaiming the middle reaches of the plain areas will be of great significance in promoting the economic exploitation of the lower reaches of the coastal area.

(2) Up to now, the most intensive human activity is concentrated in the two big cities, Beijing and Tianjin, and some local industrial areas in between, with harmful environmental effects recognizable in these areas and the downstream and downwind sections of the surrounding areas. Generally, water and air pollutions as well as ecosystem disturbance are of limited extent. This is one of the important characters of the environment status in the BTB area. However, if urbanization is allowed to develop between Beijing and Tianjin and between Tianjin and Tanggu to form a continuous metropolitan belt, then serious subsequences will not be avoidable, i. e., the cities

would not be able to get rid of the effect of self-pollution and the environmental quality would become deteriorated. For this reason, it is of fundamental importance to maintain the dumb bell-shaped structure of the BTB area.

(3) Surrounding the dumb bell-structure pattern of the city group, of which

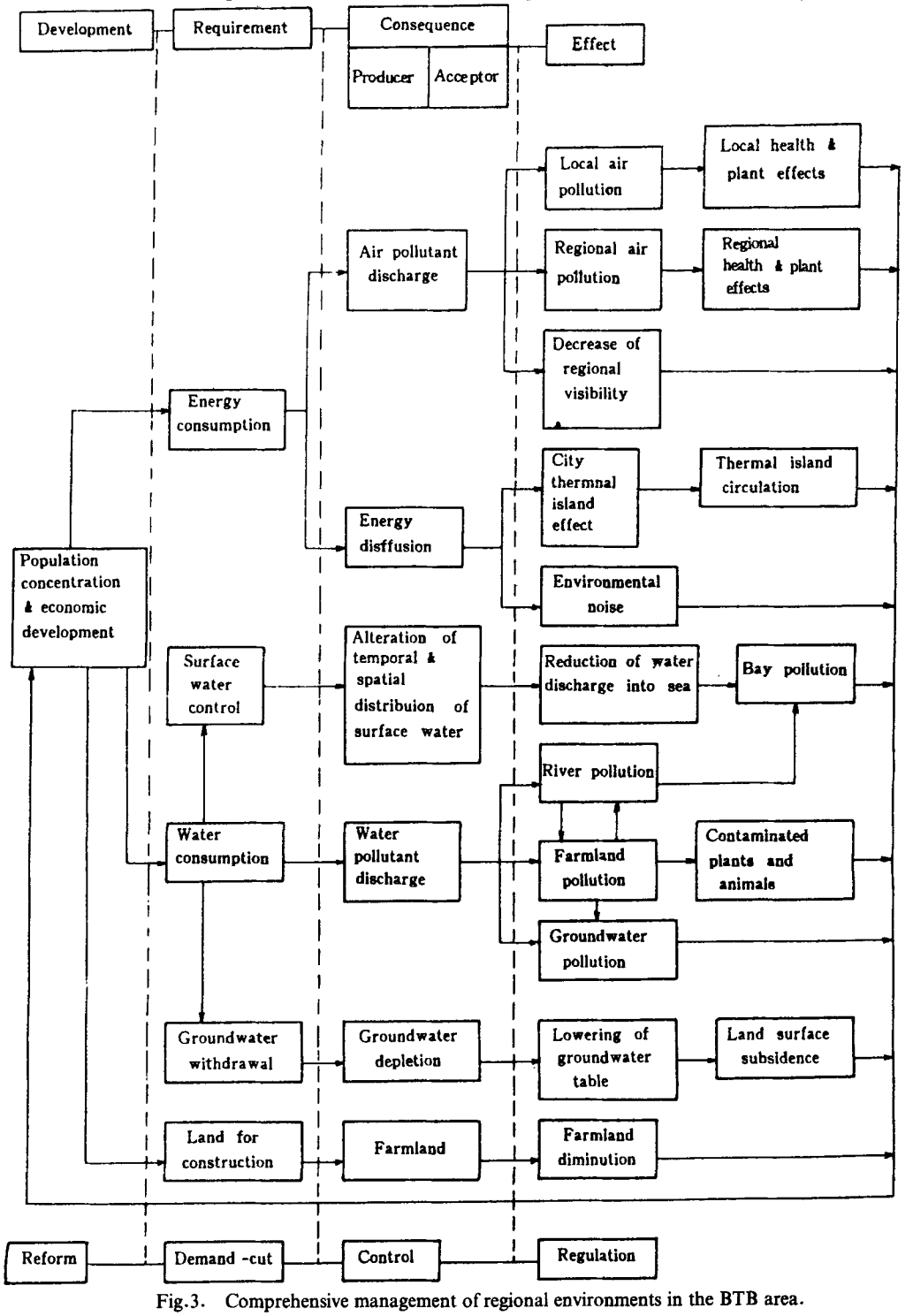


Fig.3. Comprehensive management of regional environments in the BTB area.

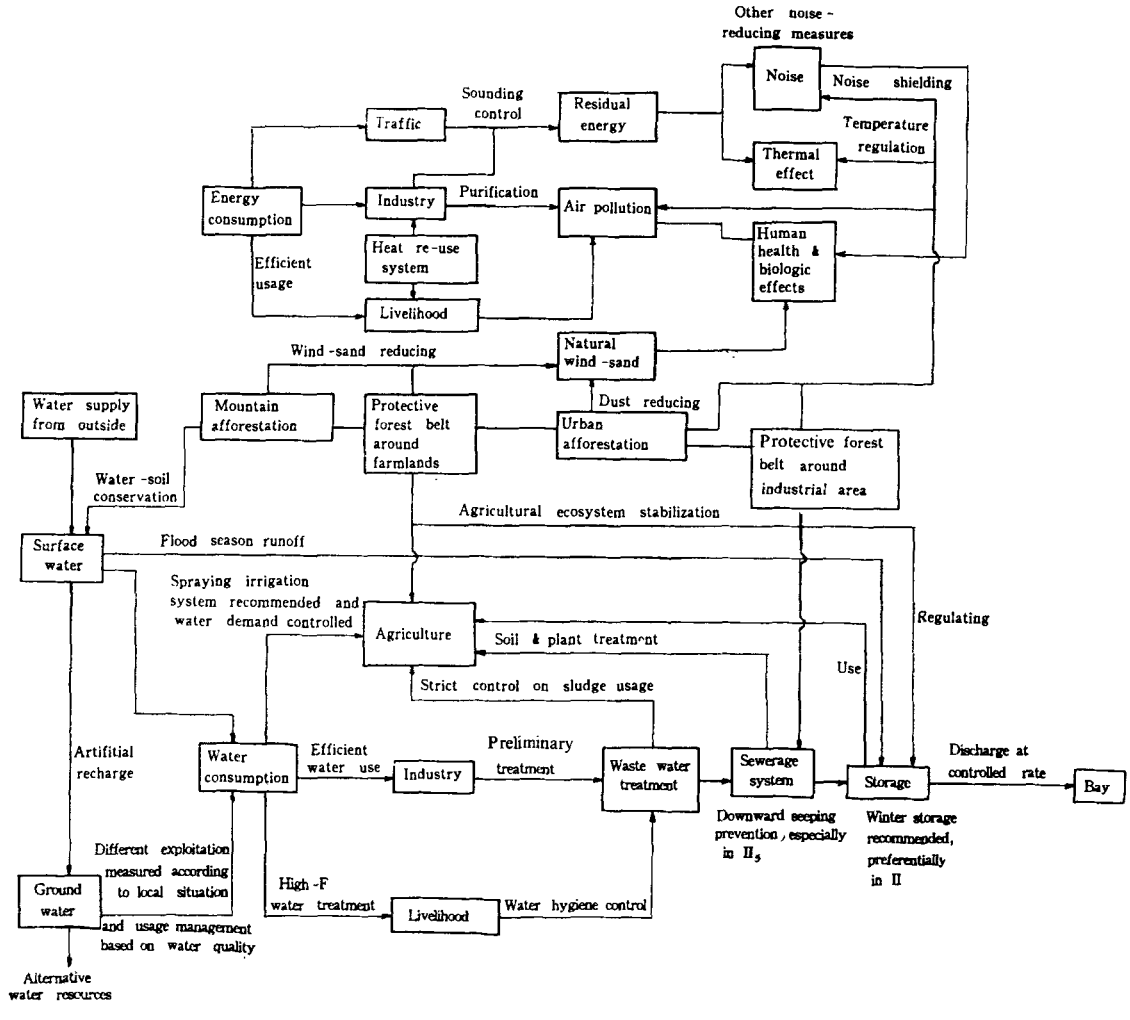


Fig.4. Control and regulation diagram of the network ecosystem in the BTB area.

Beijing and Tianjin are the two major centers, are green farmlands which are in turn surrounded by mountain forest and grassland and bay waters. From the environmental point of view, such a ring structure with an internal regulating function, regarding either energy or mass transfer, among various rings has a positive effect on the purification of natural environment. If this regulation function would once be destroyed, the ring-to-ring equilibrium would be disturbed, resulting in deterioration of environment pollution and disbalance of the ecological system. Therefore, to maintain the equilibrium among the various rings is of primary importance for environmental protection in the BTB area.

(4) The utilization of land in the area should be based on the principles: the utilization must be conformable with environmental function, and the resulting environmental effect as a result of exploitation should be tolerated by the surrounding areas.

Principles of comprehensive protection and reclamation

In view of the highly dense population in the Beijing-Tianjin area and the environmental effects produced by increasing demands for energy and water resources, different management policies, with emphasis on either reclamation or demand-cut or control or regulation are formulated according to the realistic situation of each specific environment area (Fig. 3).

Principles of stabilization of the ecological system

To maintain a stable network ecosystem is of special significance in solving environmental problems and improving the environmental quality of the BTB area (Fig. 4).

Acknowledgements

Thanks are due to Prof. Liu Dongsheng for his instruction and help.

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