Combined methods for Amur River pollution assessment. Ecosystem approach.

Kondrajeva Lubov
Institute of Water and Ecological Problems, Far Eastern Branch of Russian Academy of Sciences

Introduction

The key aspect of ecological problems of Priamurje is associated with a combined pollution of the Amur River with substances and organic compounds of various origin. Water and fish quality indicates the destruction of natural complexes under anthropogenic impact in Priamurje and the disruption of inner processes dynamics in the rivers.The Amur River pollution becomes an important factor of ecological risk for vital functions of all aquatic organisms including fish fodder supply and fish resources reproduction, creates certain difficulties for water treatment.

Intensive anthropogenic impact on hydrosphere and global-scale pollution of natural waters makes quite important and urgent the survey of processes in inner water reservoirs and mechanisms of organic matter destruction there. Many organic matter destruction processes have been studied mainly in the water column, i.e. in homogeneous media under a limited set of physical-chemical factors. The boundary water – bottom layer is studied rather well from the point of view of organic matter mineralization in the sediments, accumulation and migration of toxic heavy metals. Biochemical assessment of pollution in water ecosystem is mainly based on the investigation of complex function of bottom sediments and hydrobionts (bioaccumulation). Appearance of new classes of pollutants significantly influence species diversity of biotic complexes and peculiarities of bacterial metabolism in organic compounds studied earlier, depending on their localization. Such aspects as concentration ratio of certain substances, substrate inhibition, secondary pollution by metabolism products gain special significance. Seasonal dynamics of microbial communities structure, changes of their dominant forms and extreme conditions in transitional zones cause formation of products and their combinations, earlier unknown. Processes of destruction of allochthonous and autochthonous organic matter in contact zones: water – atmosphere, water – ice and water – surface of suspended solids need further detailed study.

Water – atmosphere contact zone

Among many abiotic factors UV-radiation plays an important regulatory role in organic matter destruction in the water – atmosphere contact zone. This factor acquires great significance for water ecosystems due to anthropogenic impact on the ozonosphere. Atmosphere contamination leads to a decrease of ozone layer protective functions from disastrous influence of penetrating UV-rays. Photochemical reaction research revealed various mechanisms of aromatic compounds destruction (Tchaikovskaya et al., 2001). Under photolysis, the scission of benzoic ring occurred only at that time when a powerful laser radiation was used (Tchaikovskaya et al., 2000).

Comparative analysis of photochemical and microbial destruction of phenol is shown in Figure 1. Phenol photolysis mechanisms study showed that hydroquinone and p-benzoquinone were found among photoproducts. During microbiological destruction phenol degradation occurred without the formation of toxic products. Positive effect was obtained when UV-radiation was coupled with phenol-destroying bacteria. Under the advance UV-treatment of phenol solution for 40 minutes and further activities of microorganisms, degradation of phenol and products of its photolysis occurred.

The advantage of microbiological destruction of phenol is in aromatic ring breaking. Microorganisms are able to utilize greater concentrations of phenol, up to 0,2 g l^{-1} in 2 – 3 days interval (Kondrajeva et al., 2001). The effective photolysis occurs under low concentrations of phenol (10^{-4} - 10^{-5} M l^{-1}) and powerful radiation not typical for natural conditions. Our studies confirm an important role of microbiological destruction in detoxication of phenol compounds and photoproducts in the water – atmosphere contact zone. When the bacterial ferments activity decreases and a doze of UV-radiation increases due to global-scale processes in ozonosphere the risk of formation of toxic intermediates is raised in the course of phenol destruction in surface waters.

Complicated hydrobiont complex, found in coastal seawaters produces phenol compounds (macrophytes, microalgae) and decompose, transform these compounds (microorganisms). In shallow waters aromatic compounds transformation is controlled by multi-factor photo-biogeochemical processes, which are not yet completely studies. The salinity gradient, pH changes, stable organic matter and heavy metal ions, discharged from the river, may negatively effect hydrobionts and self-purifying processes.

Microorganisms' destruction potential depends on the origin of phenol compounds. It has been shown already that even highly active bacteria cannot decompose certain phenols of anthropogenic origin, although they easily decompose common phenol and some phenol compounds present in lignin containing plant residue (Kondrajeva et al., 2001).

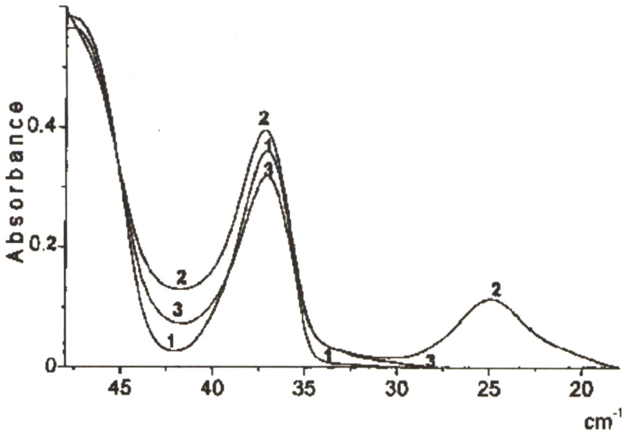

Fig. 1 Absorption spectra of phenol in water (1) and saline solutions (2) after 40 min irradiation and 24 h destruction by microbial communities in the phenol solution irradiated for 40 min (3).

Oil products might precede the formation of phenol compounds. Several oil pollution accidents were registered from 1997 to 2002. Down the Amur River stream pollutant content may significantly vary. During 1998 freeze-up maximum water pollution with oil products was registered near Bogorodskoe (0.31 mg/l), which 6 times exceeded the standard accepted for fishing water resources. At the end of freeze-up (March 1998) in the Lower Amur near the city of Nickolaevsk-on-the-Amur it was even 13 times more.

WATER - ICE CONTACT ZONE

Seasonal fluctuations of the Amur River discharge (mostly into the Okhotsk Sea in summer and through the Tatar Channel into the Sea of Japan in winter) and seasonal character of pollution in particular, influence water quality formation factors in the coastal seawaters. There are no such factors in winter as surface water run-off and water pollution from the atmosphere. Thus, the most ecologically dangerous situation on the river appears to be during the freeze-up period. It is indicated by a very specific chemical smell of fish and water in winter.

Complex research of the Middle and Lower Amur, carried out in 1997-2003 by the Institute of Water and Ecology Problems, Far Eastern Brand, Russian Academy of Sciences revealed that the Sungary tributary causes extreme pollution with its peak in the freeze-up period (Kondratjeva, 2000, 2001; Kondratjeva et al, 2000, 2003; Sirotski et al., 2002; Shesterkin, 2000; Shesterkin, Shesterkina, 2003; Yurjev et al.,1999). Mechanisms of water quality formation in freeze-up time are least studied.

For water ecosystems of Siberia, Arctic and the Far East, studies of organic matter destruction mechanisms in the water - ice contact zone are of special significance. During 5 – 6 months period of freeze-up on some rivers specific conditions are formed for glaciochemical and microbiological transformation processes of biogenic elements, destruction of suspended and dissolved organic substances and which influence hydrobionts activity and the length of toxicological effects (Kondrajeva, 2002).

Ice is a peculiar ecological niche for water ecosystems and a structural component of the cryosphere (Ivanov, 1998). Biotic complex, which is formed on the ice bottom and in its mass plays an important role in its functioning. Cryoperiphyton (algae population) actively reacts to biogenic elements input and participates in productive processes (Lebedev et al., 1981; Yuriev, 1996). Psychrophilic heterotrophic micelles organisms composing ice overgrowth serve as indicators of natural water pollution by sewage (Yuriev et al., 1999). Heterotrophic microorganisms (cryomicrobiocenoses) take a special place in substance circulation in ice, however, their role in migration, transformation and accumulation of chemical compounds of various origin is little studied.

The role of cryomicrobocenoses in the formation of water quality of the Amur River was shown for the first time in 2000-2001 winter surveys (Kondrajeva, 2002). According to the obtained data, during the freeze-up combined productive-destructive processes are formed in the cryosphere. Their scale can be compared to substance circulation in the water column and bottom sediments. The number of ice microbial communities depends on many factors, including development of phototrophic organisms on the ice bottom, presence of micro-admixtures, oil products and contact zone pollution with heavy metals.

Noticeable changes of microorganisms in number in the Amur ices were found lower the estuary of the Sungary River (China) from the Amur left bank towards the navigation channel and along the stream. The flow of pollutants coming from the Chinese territory (Heilongjang province) is distributed as far as the city of Khabarovsk and significantly impacts water quality formation and ice contamination for 220 km lower the Sungary River estuary.

According to microbiological indices minimum Amur ice contamination with organic matter was registered in January (Fig. 2). At the end of winter the number of microorganisms in ice that indicate water ecosystems pollution with organic nitrogen-containing substances and aromatic compounds increased 4-8 times and was much higher than that in the water column.

Owing to local pollution of the ice bottom with oil products the number of phenol-resistant microorganisms was 5 times greater than that of under algae development. In detritus presence 10-50 times increase of separate physiological groups of bacteria in number was also observed in ice (Table 1).

Bacteria separated from ice at different sites of the Amur River during the 2001 freeze-up revealed proteolytic activity. Among cryomicrobocenoses studied at a site located upper the Sungary mouth 27% of strains with proteolytic activity were identified, lower the Sungary mouth - 33% and near the water-tower of Khabarovsk - more than 40%.

Microbial communities resistant to ions of heavy metals (Hg, Pb, Cd) were found in ices affected by Sungary water. Model experiments with cryomicrobocenoses and separate strains of bacteria resulted in significant differences in their threshold of sensitivity to heavy metal pollution. Thus, microorganisms inhabiting ice affected by the Sungary River endured high concentrations of heavy metal ions (up to 1 g/l). The growth of microorganisms isolated from the ice of a control site (upper the Sungary estuary) was inhibited by a concentration of 100 times less. Model experiments showed that cadmium caused destruction of nitrogen-containing organic substances, broke ammonification and nitrification processes in water medium in the freeze-up period. In winter, pollution of water and ice with heavy metals can be an additional reason for reducing mineralization rate of nitrogen-containing substances and increasing the amount of ammonium and nitrite ions.

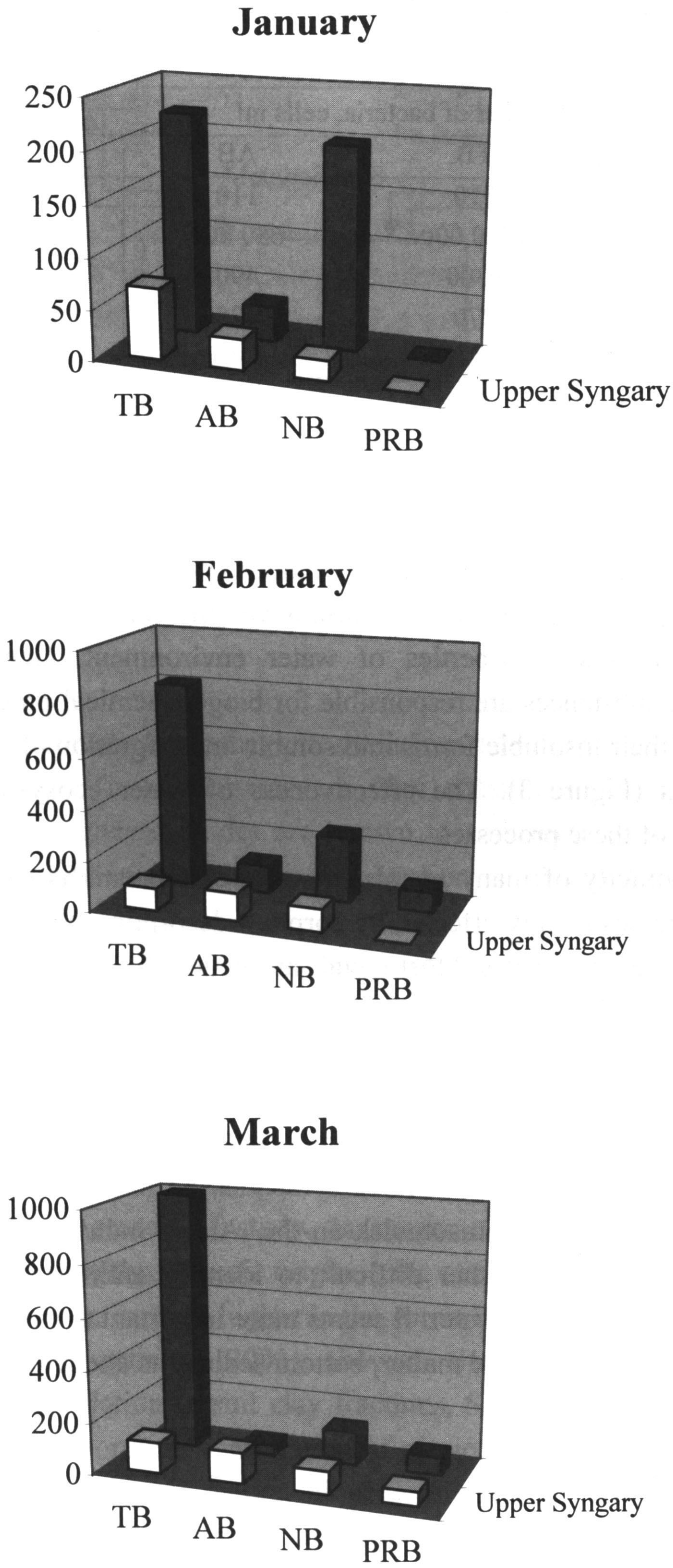

Fig. 2 Microbiocenoses number dynamics during 2001 freeze-up period on the Amur River, upper (A) and lower (B) the Sungary estuary.

Table 1 Change of cryomicrobocenoses structure depending on a character of pollution of the Amur ice bottom in the freeze-up period (TB - total number of bacteria, AB - ammonifying bacteria, NB - nitrifying bacteria, PRB - phenol-resistant bacteria).

Pollution	Number of bacteria, cells ml^{-1}			
	TB	AB	NB	PRB
Coal particles	810	110	260	80
Oil products	1220 000	650 000	940 000	380
Detritus	9300	490	1100	490
Algae	270	125	225	70
Control (pure ice)	70	30	20	0

WATER - SURFACE OF SUSPENDED SOLIDS CONTACT ZONE

Suspended particles containing organic matter, which are transferred in space and changed in time can precede the formation various volatile compounds that influence in their turn organoleptic and toxic properties of water environment. Genesis and qualitative composition of these substances are responsible for biogeochemical processes dynamics, rate of transformation of their insoluble forms into soluble and migration of persistent compounds in bottom sediments (Figure 3). The effectiveness of water ecosystems self-purification depends on intensity of these processes.

Mobility and toxicity of many metals in water ecosystems is caused by complicated biogeochemical processes mostly effected by sorption-desorption mechanisms on the surface of solid particle of different genesis. Most metals are bounded with organic suspended matter, bottom sediments or a “living substance”.

Studies of metals present in the Lower Amur waters (Chudaeva, 1995,2001) have revealed that their amounts are determined by natural fluctuations due to water run-off from the river tributaries and boggy areas. Amur water quality assessment proved that in spite of heavy pollution of the Silinka River with heavy metals, its share in overall river pollution is insignificant. The impact of Komsomolsk-on-the Amur industrial wastewater was not discovered. That is why, it is rather difficult to identify anthropogenic sources of toxic pollutants by metal ion content in water. It seems more important to trace them in the zones of their accumulation, i.e. in suspended matter, bottom sediments and hydrobionts.

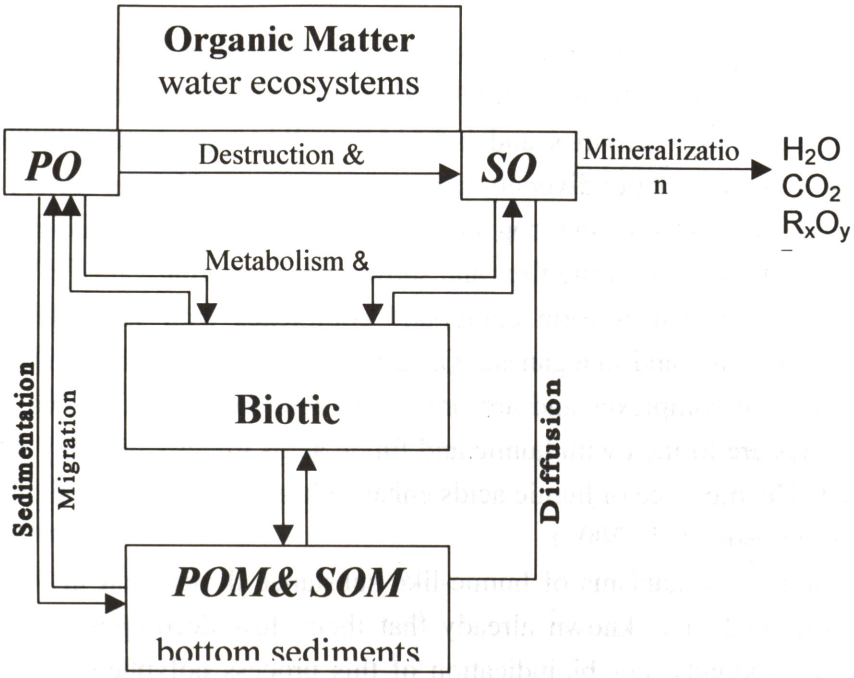

Fig. 3 Water ecosystems self-purifying and mechanisms of organic suspended matter transformation into dissolved forms.

It has been noted already that behaviour of such metals as iron and manganese depends on the season of study. These elements are very sensible to changes in water media parameters. Iron and manganese oxides are known to contribute to the migration of other elements. It should be kept in mind that iron migration is rather intensive, with suspended matter in particular.

Element composition of surface water and suspended matter, as well as total organic matter composition are well studied by geochemists, whereas biological factors and microbiological destruction processes in organic suspended matter is less studied. While moving down the river, suspended particles play an important role in transportation of mobile metal forms and dissolved organic matter.

Forms of element migration, their qualitative compositions and toxic influence on water organisms depend on the season of study. In winter, for instance, there is less copper, cadmium, zinc and lead of anthropogenic origin in the atmosphere. In summer, the content of heavy metals, iron including, is much higher in the Amur River.

Matushkina with co-authors (2003) showed similarities between iron migration behaviour and iron accumulation in soil clay fractions. Substance composition of the Amur River bottom sediments is formed by migration of erosion and soil formation products (clay minerals, organic matter of humic nature, biogenic elements, oxides, iron and manganese hydroxides). Iron, resulting from erosion and soil formation in Priamurje accumulates in finely dispersed fractions of bottom sediments. Clay fractions (particles less 0.002 mm in size) easily mix with water and are carried down the river, thus participating in suspended matter formation. Bottom sediments in the Lower Amur accumulate up to 8-10% of clay fractions. It means that the surface run-off brings iron-humic and iron amorphous compounds into the Amur River.

To make correct estimations of the river pollution with toxic elements seasonal input of these elements should be taken into consideration, as well as the origin of the bound organic matters. Economic activities and industrial and sewage water treatment in the river basin determine organic matter diversity in water ecosystems. Natural factors include seasonal input of organic wastes, soil and bog humus during spring and autumn floods. A lot of stable organic matter comes during fires and snow and ice melting.

Humic substances form compound complexes with such elements as mercury, iron, copper, lead, zinc and manganese. On the contrary, vanadium, molybdenum and arsenic do not form such complexes and are present in acid forms (Fedoseeva, 2002). When complex compounds are formed with humic and fulvic acids toxicity of many metals in water media is reduced. The presence of humic acids enhance heavy metal sorption on the suspended mineral particles (Kosov et al., 2001)

Though mechanisms of humic-like substance destruction in water ecosystems are not fully described, it is known already that their slow decomposition in water may produce phenol compounds. For bioindication of this process polyphenoloxydasa - enzyme activity and phenol-resistant bacteria growth in number can be used (Kondratjeva, 2000; Kondratjeva, 2001).

Our studies show that Amur River suspended solids are complicated biogeochemical complexes, composed of algae, micromycets and bacteria. Such biocomplexes are proved to supply water media with volatile organic substances (Table 2).

Microorganisms, which are present in suspended solids and destruct organic matter, are also able to change their activity under the influence of temperature and pollutants adsorbed on their surface. Different combinations of organic matter form a part of suspended particles and being in water play an important role. Qualitative and quantitative composition of volatile substances, formed from organic suspended matter depends on additional pollution sources, present in water as well as on adaptation level of destructing bacteria.

Our experiments showed that qualitative and quantitative composition of destruction products of biochemically mobile compounds, including glucose mostly depends on preliminary adaptation of microbial complexes in suspended solids to pollutants.

Table 2 Impact of adaptation to phenol pollution on glucose metabolism by microbiocenoses of suspensions

Characteristics of microbocenoses	Metabolism products	Products content, mkg l^{-1}	
		Glucose (1%)	Glucose (1%) +Phenol (0,05%)
Non-adapted	ethanol	54,4	25,2
	n-butanol	41,6	104,2
	iso-propanol	11,5	29,2
	n-propanol	4,2	-
	acetic aldehyde	1,0	5
	methanol	0,288	0,192
Total concentration of products		**112,9**	**163,7**
Adapted	ethanol	31,0	7,29
	n-butanol	62,5	-
	iso-propanol	2,88	8,45
	n-propanol	3,5	0,96
	acetic aldehyde	1,04	-
	methanol	0,19	x-1- 4,35*
Total concentration of products		**101,11**	**21,05**

* x – 1 - non-identified product.

Thus, in the process of bacterial metabolism of glucose mainly ethanol and n-butanol (48% and 37%, respectively) are formed on the surface of suspended solids. In the presence of phenol (0,5 g/l), more than 65% of n-butanol is educed in water and 5 times more acetic aldehyde is formed. Table 2 illustrates this.

Highly toxic ions of heavy metals may appear in water due to destruction of organic suspended mater. Thus, element migration in "the water – suspended matter" system is determined by biogeochemical processes (sorption-desorption) and different organisms participation.

Studies of the nature of organic components, discharged with suspended particles from the Amur to the Pacific seas seem to be of vital importance. Our research has shown that nitrogen-containing organic substances prevail in the Amur River pollution with biochemically labile organic matter (Kondratjeva et al., 2000). Down the River the content of persistent (stable) polyaromatic hydrocarbons is growing (Kondratjeva et al., 2003). They may be associated with suspended particles, as well as with iron-humic and iron amorphous compounds.

River – sea contact zone

Many aspects of surveys, use and conservation of world biological resources are connected with pollution problems in coastal waters, which are characterized by maximum productivity. Ecological situation in coastal areas of the Okhotsk Sea and the Sea of Japan might be worsened by two main factors: by pollutants and by their transformation products, brought by the river into the sea and the Sakhalin Island shelf development.

River estuaries are considered to function as special biological filters in the river – sea system. Large-scale processes of water mass transportation, migration and sedimentation of suspended matter, floculation, colloid particles coagulation, assimilation and bioaccumulation of different organic and toxic compounds characterize the zone of sea and fresh water mixing. Estuaries are called marginal filters (Lisitsin, 1994) as great masses of suspended particles of natural and anthropogenic origin pass through them.

Compared to many estuaries the Amur River one has suspended matter inflow specifics and peculiarities of its further distribution to the north and south. The Amur liman is a transit and accumulative system that absorbs 95% of discharged solids with a high concentration of organic matter (Dudarev et al., 2000). 23 mln tons of solid matter come to the liman annually, and then distributed between the Okhotsk Sea and the Sea of Japan. When the river is not frozen the main discharge of solids is in the Okhotsk Sea direction (5.6 mln tons), and 71% of suspended matter is accumulated in the liman itself. When the river is frozen 2.28 mln tons of suspended matter is discharged in the direction of the Sea of Japan, 0.48 mln tons of which are carried out beyond the liman boundaries.

Complex quality assessment of water in the Amur liman was carried out in August 1997. Microbiological and hydrochemical parameters were used. Organic matter distribution there is shown in Figure 4. Significant differences in water quality formation were found between discharge directions into the Okhotsk Sea and the Sea of Japan. The major portion of organic matter of different origin and maximum phenol compounds content were identified in the main stream opposite the Orimif Island.

Organic matter, difficult to mineralize, was found discharged more into the Okhotsk Sea than to the Sea of Japan. The fact is also proved by high number of phenol-resistant bacteria in water samples, taken near Ozerpakh village. Higher content of labile forms of phenol compounds (0.009 mg/l) was also evident. Bioindication did not reveal labile nitrogen-containing organic matter in the water samples. Near the Pronge village (Sea of Japan direction) hydrobiological water quality parameters were much better. Phenol content was twice less than near the Ozerpakh village.

In fresh and seawater mixing zone at the Sakhalin traverse water quality improves as compared to the Orimif Island area. Nevertheless, labile and persistent (steady) organic substances are registered. Phenols are not found.

These though preliminary data allow concluding that in summer time River discharge cause active processes of organic matter production and destruction in the shallow Amur River liman. The main portion of persistent (steady) components is carried out in the Okhotsk Sea direction (Figure 4). A much lower self-purifying parameter is also registered here.

Seasonal dynamics of organic matter distribution in the Amur main stream and its discharge into the liman is shown in Figura 5. Microbiological parameters serve for trend lines.

According to surveys by V.A. Chudaeva in 1982 and 1989 heavy metals discharge from far eastern rivers into the Sea of Japan can be represented as

Fe>Mn>Cr>Cu>Ni>Zn

Iron, manganese, zinc and lead are carried into the Okhotsk Sea with suspended particles, whereas chrome, nickel and cadmium are dissolved. It has been estimated that the Amur River annually discharges into the sea 32 300 tons of dissolved forms of 9 main elements and 840 000 tons in their suspended forms. The figures show that 25 times more of these elements are carried downstream with the suspended particles than in the dissolved form (Chudaeva, 2001).

That is why the study of organic mineral complexes in suspended matter, bottom sediments, carried out into the sea with ice and accumulated in hydrobionts seems important in the overall survey of sea water pollution with toxic elements, discharged by the river.

The amount of iron discharge into the Pacific seas, especially with suspended particles is rather high. Forms of iron ions migration and their behaviour in the river – sea system will by and large depend on production and destruction processes relations and several physical and chemical factors (oxygen, temperature, pH, salinity gradient, etc.)

The amount of iron, carried into the coastal waters might significantly influence primary production dynamics and organic matter destruction. It is known that when oxygen is limited organic matter destruction rate depends on SO_4^{2-} and Fe^{2+} ions as acceptors of electrons. Such zones are characterized by active processes of sulfatreduction and ironoxidation.

Owing to them the concentration of dissolved organic matter in deep waters may be high, as well as the concentration of toxic heavy metals might grow. On the other hand, when water mass in enriched with oxygen, i.e. with the growth of phototrophic organisms (phytoplankton), iron-manganese bacteria may be active as well and may transform iron oxides into hydroxides $Fe(OH)_3$.

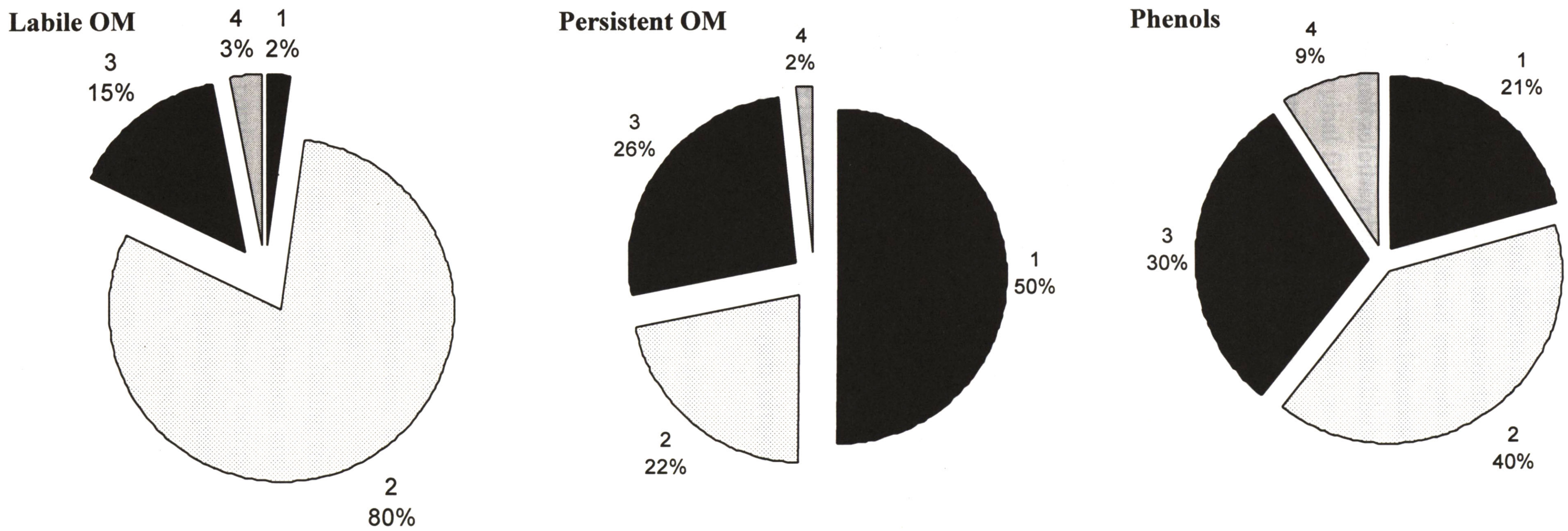

Fig. 4 1 – in the direction of the Okhotsk Sea (Ozerpakh village); 2– fresh and sea water mixing zone (Orimif Island-shallow waters), 3 –Sakhalin traverse; 4 – in the direction of the Sea of Japan (Pronge village).

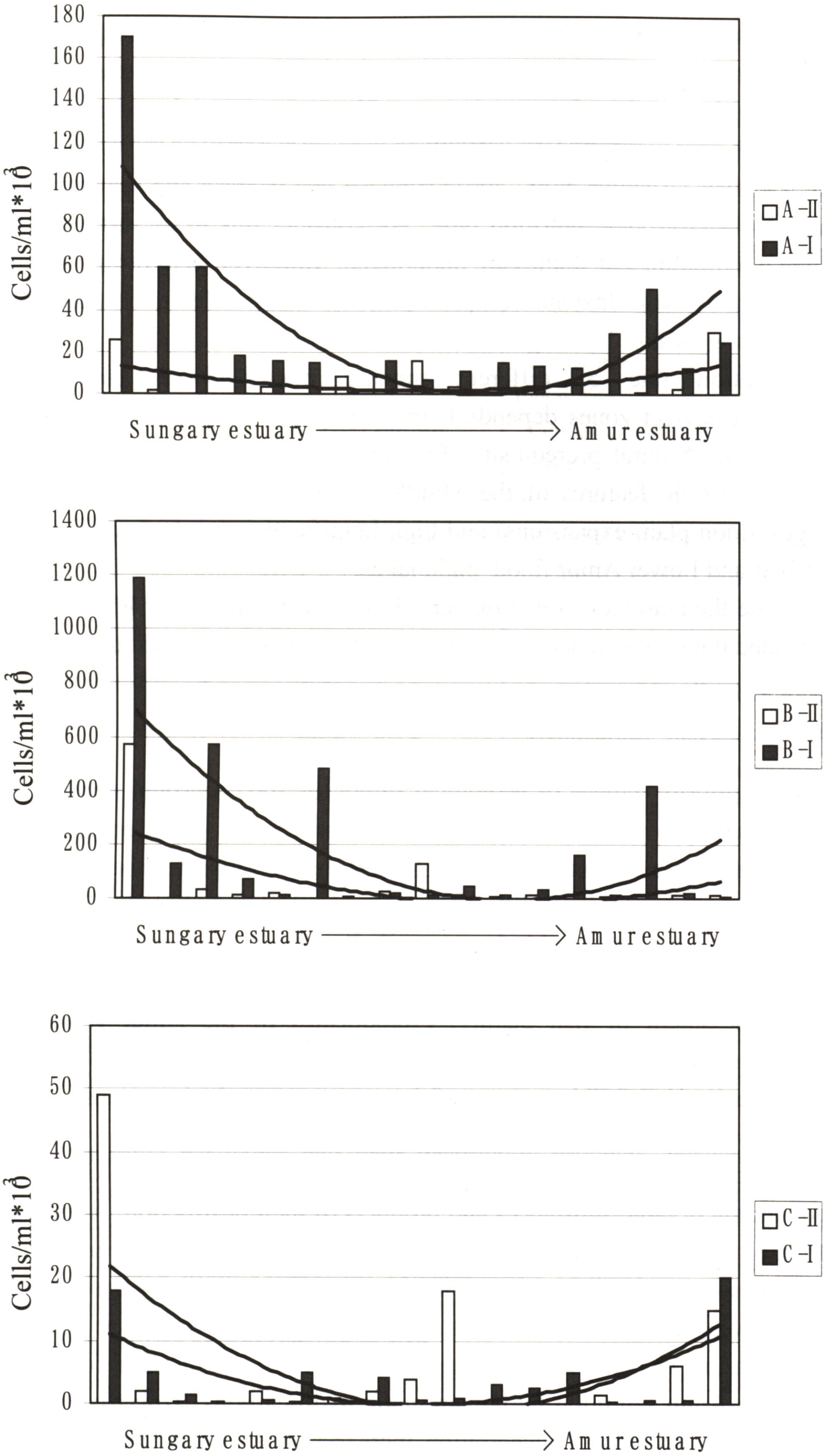

Fig. 5 Distribution of indication groups of microorganisms in the Amur River ecosystem from the Sungary River mouth down to the Amur liman in summer (I) and winter (II): A – proteolytic and ammonifying bacteria; B – nitrifying bacteria; C – phenol-resistant bacteria.

The role of microbiological processes in iron migration forms in biochemical barriers has been studies in Priamurje underground waters, rich in iron and manganese. It has been proven that the transformation of dissolved forms of iron into non-dissolved may be speeded up by enhancing the activity of a special group of iron-manganese bacteria with underground water aeration (Kondratjeva, Kulakov, 1999).

Some scientists (Agatova et al., 2001) suppose that in fresh and seawater mixing zones algae change to heterotrophic nutrition type. We consider this to be just a hypothesis until more detailed microbiological studies are undertaken. Moreover, heterotrophic bacteria with a well-developed hydrolytic enzyme complex play the main role in destruction of organic matter of different genesis.

Transformation rate of different organic matter forms (autochthonous and allochthonous) in contact zones depends both on physical-chemical factors and activity of bacteria-destructors. Natural prerequisites for the important role of humic acids are linked with landscape specific features of the Middle-Amur Lowland, the Amur River drainage system (boggy floon plain expansions) and high humification level of some streams like the Tunguska River and Lower Amur flood plain lakes.

To evaluate the amount of toxic matter, discharged by the Amur River into the sea, the role of suspended humic substance forms, bound with toxic elements should be studied.

INTERDISCIPLINARY RESEARCH

To choose priority indices of ecological safety, in 2002 seasonal surveys of the Amur water and fish quality by combined methods were undertaken. «Landesverband der Inneren Mission E.V.» charitable organization (Munster, Germany) supported the work.

Bioindication was combined with the present physical and chemical methods (IR – and UV – spectroscopy, gas and liquid chromatography, atomic-absorptive spectrometry). Fish and microorganisms were used as indicators. 12 indices were applied for ecological and toxicological assessment of fish quality. Prerequisites of the Amur River pollution by persistent organic compounds were analyzed. Transboundary pollution of the Amur River from adjacent territories of China, wastes from power sources, river transportation services and forest fires were admitted to be the most important factors.

The method of biodiagnostics confirmed a high level of the Amur River pollution with nitrogen-containing organic substances and products of their destruction. At many sites of the Lower Amur oil products concentration exceeded the permissible concentration level. The analysis of seasonal contamination of the Amur River with persistent polyaromatic hydrocarbons revealed that in summer, at some sites of the River lower Khabarovsk, their overall concentration was 10 times greater than in winter. In summer forest fires play an important role in Amur pollution by polyaromatic hydrocarbons. Towards the Amur estuary the polyaromatic hydrocarbon concentration increases in all water samples of crossed and longitudinal River profiles.

It has been shown that in summer and winter all fish quality indices correspond to sanitary-hygienic standards and food permissible concentrations except for mercury. In winter mercury concentration in fish caught in the main stream was 2 times higher than that in sub-streams. Total natural and technogenic impact on the aquatic environment quality causes fish polytoxicosis in winter.

Table 3 Complex fish quality assessment in the Amur River during 2002 freeze-up period

Parameter	Parameter values (max)	Fish
Smell intensive	Acrid	Leuciscus waleckii, Lota lota, Parasilurus asotus, Hemibarbus maculates
Microorganisms	2000 - 6000 cells/g	Leuciscus waleckii, Lota lota, Parasilurus asotus, Hemibarbus maculates
3-methyl-amine	2,4 – 6,2 mg/kg	Leuciscus waleckii, Lota lota, Parasilurus asotus, Hemibarbus maculates
Volatile azoth substances	290 – 410 mg/kg	Abramis brama, Hemibarbus labeo
Histamine	19,7 – 22,0 mg/kg	Abramis brama, Hemibarbus labeo
Heavy metal composition in fish muscles (mg/kg) Pb Hg Zn Cu	0,02 – 0,13 0,56 – 0,72 10,2 – 10,8 1,18 – 1,41	Lota lota, Hemibarbus labeo Hemibarbus maculates, Parasilurus asotus Cyprinus carpio Abramis brama
Chlororganic pesticides	0,0623 – 0,0751 mkg/kg	Parasilurus asotus, Hemibarbus labeo

Maximum diversity of toxic components is usually registered in fish caught in the Amur mainstream. Change of organoleptic properties of fish occurs in the freeze-up period under complex contamination of aquatic medium by chlorine-containing pesticides and ions of heavy metals.

Chlorine-containing pesticides and their destruction products, hexachlorocyclohexane and its isomers were identified in different fish species, caught in the Amur mainstream. Pesticide concentration was much high in winder than in summer. Gas and liquid chromatography revealed multi-component contamination of muscular tissue in some fish. Beside chlorine-containing pesticides, significant amounts of other high-molecular not-identified compounds were also registered in fish.

Our data show that concentration of hexachlorocyclohexane and D.D.T. pesticides in fish caught in the Amur in winter is comparable with respective data on fish contamination in British rivers, before the industrial activities were limited there in 1972. Pesticides are able to accumulate and transport throughout the trophic chain, and thus appear in fish. Significant winter changes of fish organoleptic characteristics can be attributed to substance exchange disturbance, as well as to pesticides decomposition products, present in fish. Agricultural complexes in China along the right bank of the Amur River supply most of the pesticides.

Volatile organic substances of different groups, found in fish cause the formation of its peculiar chemical smell in freeze-up period. Concentration of 3-methyl-amine, registered in fish with a "chemical" smell, was much higher in winter than in summer. All the fish caught in the Amur mainstream in the Nanai District contained high 3-methyl-amine concentrations ranging from 2.4 up to 6.2 mg/kg. 3-methyl-amine does not only cause "chemical" smell, but also is considered to precede carcinogenic nitrosamines, especially when nitrates are abundant in water. Permissible nitrosamine level in fish products should not exceed 0.003 mg/kg.

Bioindication methods revealed seasonal fluctuations in Amur pollution with heavy metals and pesticides, which are known to be transported with suspended matter to the sea and accumulated in the bottom sediments. Then, owing to biogeochemical processes they migrate through trophic chains, thus damaging biological resources and endangering our health.

Based on correlation of international experience and Priamurje surveys data on natural water pollution, including new interdisciplinary research data from Lower Amur ecological situation survey, the following pollution parameters could be recommended as a priority study:

- Water – polyaromatic hydrocarbons, polychlorinated biphenyls, nitrosamines;
- Fish – chlororganic pesticides, methylated amines, ions of heavy metals (cadmium, mercury, lead)

These priority parameters should be considered while developing various social and economic programs, ecological and health risks assessments (Kondratjeva, 2003).

The following priorities for the Amur River research can be singled out:

1. Transformation mechanisms of organic matter of natural and anthropogenic origin.
2. Analysis of biocomplex population long-life dynamics
3. Accumulation and migration mechanisms of toxic substances
4. Development of regionally acceptable standards of pollution
5. The Amur River discharge impact on coastal marine bioresources
6. Ecological feasibility study for new effective and safe water treatment methods
7. Revealing ecological and social factors that influence Priamurje population sick rate.

The overall goal for the research trends mentioned above is to reduce ecological risks for the people. Sustainable development of the Russian Far East and the success of many social and economic programs targeted to secure ecological safety and ecological risks reduction will depend by and large on joint efforts of many specialists in Russia and abroad, experts in environment monitoring and conservation, water ecosystem functioning laws.

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