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The responses of hydro-environment system in the Second Songhua River Basin to melt water

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Based on the continuous monitoring data of hydrology and water quality in the period from 1972 to 1997, the responses of hydro-environment system to melt water in the Second Songhua River basin were derived. Because of melt water, the water quality in the Second Songhua River is good and changes very except that the contents of Hg and Mn in the water are higher. The contribution of melt water to the water fluxes in the Second Songhua River basin is distinct: the water flow in April increases remarkably, reaches the peak in the upper reaches. The pollutant contributions and water pollution indices (WPIs) of the Second Songhua River in April are high in the upper reaches while that in the lower reaches are low. The responses of hydro-environment system to melt water of that basin are affected by content of packed snow and the underlining surface systems.

The responses of hydro-environment system in the Second Songhua River Basin to melt water YAN Denghua, DENG Wei, HE Yan (Northeast Institute of Geography and Agricultural Ecology, CAS, Changchun 130021, China) Abstract: Based on the continuous monitoring data of hydrology and water quality in the period from 1972 to 1997, the responses of hydro-environment system to melt water in the Second Songhua River basin were derived. Because of melt water, the water quality in the Second Songhua River is good and changes very except that the contents of Hg and Mn in the water are higher. The contribution of melt water to the water fluxes in the Second Songhua River basin is distinct: the water flow in April increases remarkably, reaches the peak in the upper reaches. The pollutant contributions and water pollution indices (WPIs) of the Second Songhua River in April are high in the upper reaches while that in the lower reaches are low. The responses of hydro-environment system to melt water of that basin are affected by content of packed snow and the underlining surface systems. Key words: snow and ice; water quality; melt water; hydro-environment; Second Songhua River CLC number: X143; X522 1 Introduction Ice and snow, which contain the dust deposit of a whole winter, are the historic records of air pollution (Taraskevicius, 1998). Ions are changing when the snow and ice are packed or thawed (Harrington and Bales, 1998a; 1998b). At the same time, the underlining surface system, which accepts the melt water, experiencing the processes of being frozen and thawed, its chemical and physical features were changed (Hudson and Golding, 1998). In the area where the temperature goes up quickly, the melt water is concentrated. With the development of hydrological process, the melt water must take great effect on the hydro-environment system of the catchment. Singh H (1997) has studied snow and glacial-melt contribution to Chenab River, West Himalayas; Liu Fengjing and Cheng Guodong (1999) have researched the hydro-process of flow and the thawing snow of the Urumqi River, Tianshan Mountains; Helliwell R C and Soulsby C (1998)have studied the influence of snow on the hydrology and hydrochemistry of the Allt a´ Mharcaidh, Cairngorm Mountains, Scotland. All these studies show that the melt water takes great function on the watershed or catchment. The Second Songhua River (Sub. as SSHR in the following text) is one of the tributaries of the Songhua River, which has snow between October and April of the next year, and its total snow period is half a year and the depth of snow is above 20 cm (Wang, 1999). The melt water in SSHR basin is the important water source for agriculture and industry and exerts distinctive effect on the hydro-environment systems of the basin as well. Other authors studied the responses of hydro-environment system of a basin to melt water with respect to chemical and physical processes. However those researches are focused on the catchment of alps and not systematic. So the studies on the melt water in the mid-latitude basins are very important, as are the reference to the watershed management and the researches of evolution of watershed. 2 Study area SSHR originates from Baitou Mountain, the highest peak of Chan gbai Mountains and runs into the Songhua River at Sanchahe. It is 790 km long with a watershed area of 78,182 km2. SSHR basin is the base of the industry and agriculture of Jilin province, China. It is located in the eastern part of Eurasia continent that belongs to the humid temperate zone. The topographic relief of the basin is high in the east and low in the west. The geological conformation of the alps in the eastern part and the hills of central part of the basin is very complex, which belongs to north-east, north China platform, semi-geosyncline of Jilin in Haixi period and drap zone of Mesozoic respectively. The western part belongs to Songliao col. SSHR basin belongs to humid and semi-humid temperate zone: precipitation of the upper reaches of the basin, Changbai Mountains, is 1,000 mm and bayou 400-500 mm only; the precipitation concentrates in summer. As SSHR has many tributaries, the water of the basin is plentiful. The river network is arborization and the largest tributary is the Huifa River that originates from central part of Longgang Mountains in Qingyuan county, Liaoning province and runs into SSHR at Toudaogou in Huadian City. The Huifa River has a length of 289 km with a watershed of 16,314 km2 (Figure 1). Generally speaking, the upper reaches of the SSHR basin is mountainous with rich forest resources and great water conservancy projects; the middle and lower reaches of the basin are morphologically dominated by hills and plains with rich mineral resources, fertile soil, dense population as well as developed industry and agriculture (She et al., 1982a). 3 Materials and methods 3.1 Monitoring and analysis Four water quality-monitoring sections namely Baishan, Yizhamen, Fengman and Ganshuigang were set up over SSHR. Baishan is located on the upper reaches above Baishan City; Yizhamen above the bayou of the Huifa River; Fengman the middle reaches of the Songhua Lake on SSHR; and Ganshuigang above the bayou of SSHR (Figure 1) Three sampling points namely left, middle and right (facing the lower reaches) were planned on Ganshuigang and Fengman respectively while one sampling point (on mid-line of the river) on Baishan and Yizhamen respectively. The indices were derived by international common method. The flows of the river were inspected in phase. 3.2 Data processing Data processing was finished with EXCEL97 and SPSS9.0. Abnormal values were eliminated with CRUBBS after the data being input into computer, data were organized with year and then tested the data. In order to compare different values, this paper has designed two indexes: weighed indexes of wa-ter quality (sub as WAC in the following text) and weighed pollution indexes (for short as WPI in the following text). 3.2.1 WAC To eliminate the effect of the river flow (or reservoir capability) difference in different periods on calculating the average water quality indices, the WAC is defined. To de-rive the WAC, the first step is to get the product of the water quality index and the river flow (or reservoir capability) in the same period slice; the second step is to get accumulations of products derived from the first step and the river flow (or reservoir capability) of the studied period respectively, then the WAC is the ratio of accumulations of products and the river flow (or reservoir capability) derived from the second step. For pH-value, the first step is to change the pH-value into the contents of the [H+], then calculate the WAC of the contents of the [H+], and finally revert into the pH-value. 3.2.2 WPI WPI is just the ratio of some actual water quality index in certain period slice and the WAC of the same water quality index in a year. 4 Results and discussion 4.1 Survey of water quality The WACs of SSHR were calculated based on the data between 1972 and 1997 (Table 1). The water quality was assessed by the standard of surface water quality of China (GHZB1-1999). The pH value, DO, BOD, NO3-N, As, F and sulfide in the SSHR water reach level I; CN-, Cr, Cu, Zn, Cd, Pb level II; AR-OH, Fe level III; Hg level VI; and Mn level V. This was caused by the higher content of Fe, Hg, and Mn in background (She et al., 1982a). In total, the water quality of SSHR is good. 4.2 Response of the changes of fluxes to the melt water supply The period between June and September in a year is the rainy season of SSHR basin. Before the rainy season, the river is mainly replenished by melt water. From Figure 2, we can find the response of water flux variation to melt water in SSHR basin is distinctive. In April, the water flow of each point of the SSHR goes up remarkably, Baishan and Yizhamen have the highest water flux. With the melt water running down, the water fluxes of the middle and lower reaches of the SSHR increase ulteriorly. The water fluxes of Fengman and Ganshuigang still increase in May and June. 4.3 Response of the water quality of the river to melt water in the basin Taking Baishan as an example, the responses of the variations of water quality to melt water were discussed based on the ratio of pollutant contribution and WPI. 4.2.1 Ratio of pollutant attribution The melt water in the basin brings the pollutants stored in the packed snow and eluviated from the soil into river, this process belongs to the non-point pollution. It led April being the largest pollutant contribution (Table 2) of a whole year. Except for CN-, F, Fe, the pollutants contributions in the basin in April were larger than that in March and May, and larger than those of the average (1/12×100% = 8.33) except Pb. Having been frozen and thawed, the surface of soil becomes very loose, has larger specific surface area to meet the water sufficiently, which makes the eluviation in the basin much stronger for more melt water with the development of freezing and thawing. What is more, the pollutants stored in the snow in a whole winter run into river together. However, the peak content of CN-, F and Fe in the water in the SSHR caused by the melt water were late, the ratios of the contents of these pollutants in May and April are 1

7.41, 7.77 and 1.60 respectively. Mainly the features of the environmental chemistry of these materials caused this, but the main dynamics are still the melt water. Though the content of Pb of the water in the SSHR in April is lower than that in March and May, the total content is less, which indicates that atmosphere and soil in the basin are not the main sources of the pollutants to the water in the SSHR. 4.3.2 WPI The balance of the erosion and dilution of the melt water in the basin restricted the changes of the contents of pollutants in the water of SSHR supplied by the melt water in the basin. From Table 3, the results were derived that the contents of SS, COD, BOD, Cu, Zn and Pb in the water of SSHR in April were greater than those of the yearly average and also greater than those in March and May. This indicates that the eluviation is stronger than the dilution. The contents of NO3-N, AR-OH and Hg in the water of SSHR decrease month by month between March and May, and F in the water in SSHR in April is much less than those in March and May. The evolutions of contents of CN- and Fe in the water of SSHR were the same as the changes of pollutants contribution ratios. 4.4 The quality of melt water in different reaches of the basin The differences in the hydro-sub systems and the sources of pollutants lead the water qualities in different reaches of the basin to be diverse in COD and Cu in the water of the river whose pollutant contributions are the greatest in April were selected for analysis (Table 4). The water qualities in the reaches of the SSHR above Baishan are faintly affected by the wastewater of industry and agriculture and mainly affected by the function of geo-chemistry, and the water qualities in the reaches of SSHR below Fengman are strongly affected by the wastewater of industry (She et al., 1982b). The wastewater makes up the ice-storage below the mouth of smear in winter and the wastewater rushes down when ice and snow were thawed. The pollutant contributions and WPI of Baishan and Yizhamen in the upper reaches of the basin are isochronous. The pollutant contribution and WPI in April are greater than those in March and May, and those in May were smaller than those in June. The evolution of Cu in the water of the middle and lower reaches (Fengman, Ganshuigang) of SSHR are the same as that in the upper reaches, however, they are not extensive to the upper reaches. The evolution of COD in the water of the lower reaches is the same as that in the upper reaches, but in the middle and lower reaches of the basin, the pollutant contributions of COD in March are greater than those in April and May, mainly due to the pollutant source and the pushing down process of melt water. The sources of pollutants in the lower reaches of the SSHR basin are diversifying and the pollutants in the upper reaches of the basin continuously push down (Table 5). 4.5 Yearly evolution of water quality May is the key period of the drainage agriculture in SSHR basin while the water source of this period is melt water, so the evolution of water quality in May in Baishan was taken as the example and Ec and BOD of the water of SSHR were selected. The yearly evolution of BOD and Ec of the water changes greatly. The contents of BOD and Ec in water reached their peak in 1993 within the whole monitoring period and BOD in the water got the lowest value in 1995. The extent of change of BOD and Ec had the trend of rising up; this means the water quality of SSHR is wavy in the actual period, but the collectivity content decreases. In total, the water quality is improving (Figure 3). 5 Conclusions The water quality of SSHR is good and the yearly evolution is great because of the melt water. The contents of Hg and Mn in the river water of SSHR are high. The contribution of melt water in the SSHR basin to river fluxes is instinctive. The flow of the whole river increases remarkably in April and the flow in the upper reaches of the basin reached the peak. The melt water in the SSHR basin leads the high pollution contribution and WPI of most pollutants in the water, however they are lower in the middle and lower reaches of the SSHR. The effect of melt water in the basin to watershed hydro-environment system results from the content of the packing snow in the SSHR basin and the bottom situation of the basin where the melt water passed. References Harrington R, Bales R C, 1998a. Interannual seasonal and spatial patterns of meltwater and solute flowes in seasonal snowpatch. Water Resour. Res, 34: 823-831. Harrington B, Bales R C, 1998b. Modeling ionic solute transport in melting snow. Water Resour. Res., 34: 1727-1736. Helliwell R C, Soulsby C et al., 1998. 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关键词： snow and ice; water quality; melt water; hydro-environment; Second Songhua River

