SNOW DUMPING SITE USING RIVERBANKS AND THEIR INFLUENCE ON THE ENVIRONMENT OF RIVERS

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ABSTRACT

In this research, we investigated (1) the current conditions of snow removal operations and amount of snow carried to dumping sites and (2) the degree of pollution of the snow which is accumulated on roadsides and snow dumping sites on riverbanks. Then, we examined the influence to the river environment when river space is used for a snow dumping site. Also, we examined the administrative measures needed to minimize such negative effects.

From the results of the investigation on the level of pollution of accumulated snow, the melt water of snow sampled along roads was found to contain a high density of suspended matter. There was also a high level at heavy metals and TOC. In addition, the nutrient salt often exceeded the critical level in which entrophication occurs. Beyond this, it was found that much garbage was included in accumulated snow. Sand was found in snow along the streets and household garbage, such as glass, vinyl, metals, and paper were found in both a residential area and an amusement area.

Therefore, it is apparent that the accumulated snow is greatly polluted by human beings. This raises the concern that over time the accumulated pollutants may cause severe environmental deterioration. Even today, it is estimated that such pollution has caused a rise in the density of nutrient salt in river and underground waters. In addition, garbage in the dumped snow deteriorates urban landscapes, and its putrefaction affects public hygiene. Thus, it is not appropriate to set up snow dumping sites on riverbanks.

However, in a city like Sapporo where there is much snowfall and urbanization has rapidly progressed, it is difficult to secure snow dumping sites other than riverbanks. In addition, the amount of snow carried to dumping sites is increasing due to growing citizens' demands for upgrading the level of snow removal and clearing operations. Thus, under such circumstances, it is not feasible to eliminate riverbank snow dumping sites.

1. INTRODUCTION

The areas in Japan which receive snow are characterized by snowfall heavier than snowfall in any other northern country (Fig. 1). The development of motorization has caused citizens' demands for increased snow removal each year. As a result, the amount of snow carried from the city to dumping sites by truck has been increasing in recent years.

The city government of Sapporo has used the riverbanks of the Toyohira River, which flows through the city center, for snow dumping. Recently, however, the mass media has reported people's concern over the impact of snow dumping upon the dumping sites and surrounding areas. This is because the quality of river water and the landscape are worsened by polluted, dirty snow being dumped onto the riverbanks in early spring, by dusts and garbage which have remained after melting, and by "deicing" chemicals which might be included in the snow.

The "river space" of the Toyohira River is utilized in three main ways: for flood control, for recreation (Photo 1), and for snow dumping. These three uses are based upon citizens' needs (Fig. 2). However, it has become impossible to completely fulfill these three purposes. The problems are as follows: in order to use the Toyohira riverbanks as a "recreational space" during the vacation weeks of May, the snow in the dumping sites must be melted before that. This is possible only when the snow is pushed out into the center line of the stream (Photo. 2). This worsens the water quality. If the snow is allowed to melt on the banks, water quality is maintained, but the riverbanks are not available for recreation until August. Furthermore, the river water increases due to the snow melt in April-June, if dumped snow remains it prevents the increase in water from flowing efficiently. It hinders flood control and therefore must be eliminated as early as possible.

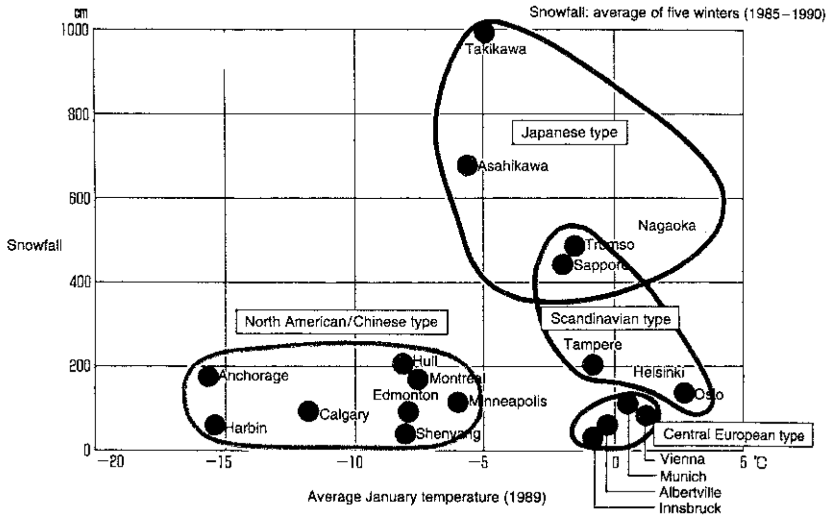


Fig. 1 The relation between accumulated snowfall and temperature in January in cities of the northern region.

Photo 1. Recreation on the riverbanks.

Photo 2. The dumping sites on the riverbanks.

Since the flood control and recreation uses do not do much damage to the water quality, the solution to the water quality problems has been to stop dumping snow. However, continued urbanization in Sapporo has made it much more difficult to find other snow dumping sites in the city center. Thus, any new dumping site is situated beyond a radius of 10 km from the city center. As a result, the trucks must travel farther. This increases the cost of snow removal and the consumption of gasoline, as well as increases gasoline exhaust. This, then, runs contrary to the world-wide environmental efforts to conserve energy.

Solutions to the problems of riverbank dumping have been difficult to find. In addition, there has been little research in Japan on snow pollution in general or on the process of how it becomes polluted. This paper, modeled on the Sapporo situation, will present research and analysis on the present state of the snow removal operations and the amount of snow carried to dumping sites. This paper will also present research and analysis on the pollution of snow accumulated in the city as well as snow in the snow dumping sites.

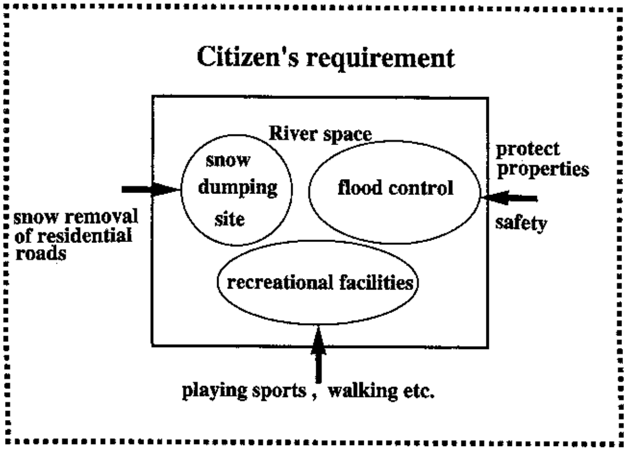


Fig. 2 The uses of the Toyohira River "river space" (Sapporo).

2. PRESENT STATE OF SNOW REMOVAL BY TRUCK AND MANAGEMENT OF SNOW-DUMPING SITES (SAPPORO).

2.1 Present State of Snow Removal

According to annual polls taken by the city of Sapporo, improvement of the snow removal ranks first among the demands of citizens to the city. Fig. 3 shows the content of the demands. 64.4 % of the citizens want more snow removal on residential roads. This is the number one request of citizens polled. Due to the narrowness of residential roads, the snow removal on these roads involves removing the snow completely.

As the roads under the city's jurisdiction have expanded, the city has had to remove much more snow by truck (Fig. 4). The snow removal by city trucks in Sapporo in the winter of 1994 covered a distance of 1,177 km, including bus routes and heavily travelled arterial roads around JR (Japan Railway) and subway stations. The removal, including transport of the removed snow by trucks, takes place 1.5 to 2 times per winter with the exception of bus lanes and bus priority routes which are cleared of snow one more time. 588.5 km of roads have been designated by elementary schools as routes for children walking to and from school. 212 km of these roads are too narrow to secure pedestrian passage throughout the winter. This snow is removed and transported by truck. This removal and transportation of snow does not include other residential roads. If snow were to be removed by city trucks on all residential roads (4,000 km of the approximately 5,000 km of road under city jurisdiction) this would cause financial hardship for the city.

To remedy the problem of snow removal on residential roads some solutions have been developed, such as a system of lending trucks to neighborhood associations for free, or a system of "snow removal partnership" in which both citizens and city share the cost of snow dumping by truck. Therefore, a way in which snow can be removed through cooperation between the city and citizens is now urgently sought.

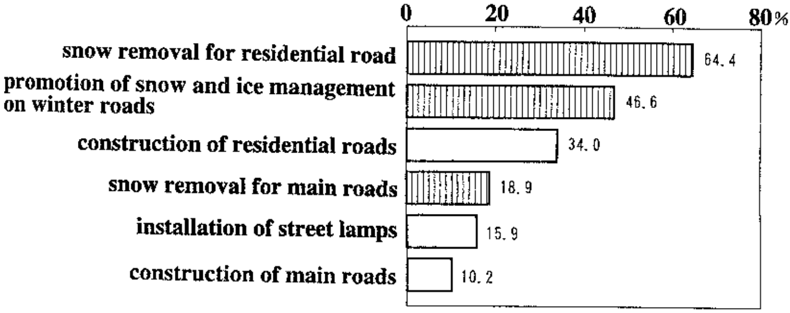


Fig. 3 The content of citizens' requirements about snow removal

Photo 3. The present situation of residential roads in winter

2.2 The Present State of Dumping Sites

Table 1 shows the location of snow dumping sites and the changes in the amount of snow removed and transported from the winter of 1983 to the winter of 1994 . There are a total of about 40 dumping sites, but the proportion of snow dumped in riverbanks versus snow dumped on land is changing. The number of dumping sites on riverbanks exceeded that on land by 10 in winter 1983, but it equalled that of land in the winter of 1989. The number of riverbank dumping sites decreases to 16, which is 6 sites fewer than that on land in the winter of 1994. Thus, the number of riverbank dumping sites is steadily decreasing. For example, 83.1 % of the snow was dumped onto riverbanks in the winter of 1983, but only 40 % was dumped there in the winter of 1994. However, the ratio of the use of riverbank dumping has decreased, there was an increase in the total volume of the removed snow with an absolute amount of 5,000,000 m^3. The importance of riverbank dumping does not become less.

Table 1 Annual changes in the number of the dumping sites and the amount of transported snow

winter season	number of snow dumping site			amount of removed snow (1000m3)			accumulated snowfall
	riverbanks	others	total	riverbanks	others	total	(cm)
1983 - 1984	25	15	38	5462.0 (83.1%)	1108.0 (16.9%)	6570.0	524
1984 - 1985	23	15	38	8292.7 (79.8%)	2101.3 (20.2%)	10394.0	488
1985 - 1986	22	16	38	7698.1 (74.0%)	2709.9 (26.0%)	10408.0	526
1986 - 1987	21	16	37	5572.0 (67.0%)	2746.8 (33.0%)	8318.8	513
1987 - 1988	21	16	37	4947.1 (67.0%)	2437.8 (33.0%)	7384.9	475
1988 - 1989	20	18	38	2458.3 (57.2%)	1837.7 (42.8%)	4296.0	311
1989 - 1990	20	20	40	5037.0 (55.8%)	3983.0 (44.2%)	9020.0	411
1990 - 1991	20	21	41	7811.0 (54.5%)	6526.0 (45.5%)	14337.0	637
1991 - 1992	19	25	44	3830.0 (49.3%)	3938.0 (50.7%)	7768.0	382
1992 - 1993	19	25	44	5116.0 (47.4%)	5676.0 (52.6%)	10792.0	465
1993 - 1994	18	28	46	4500.0 (46.7%)	5130.0 (53.3%)	9630.0	571
1994 - 1995	16	27	43	4835.0 (39.2%)	7494.0 (60.8%)	12329.0	394

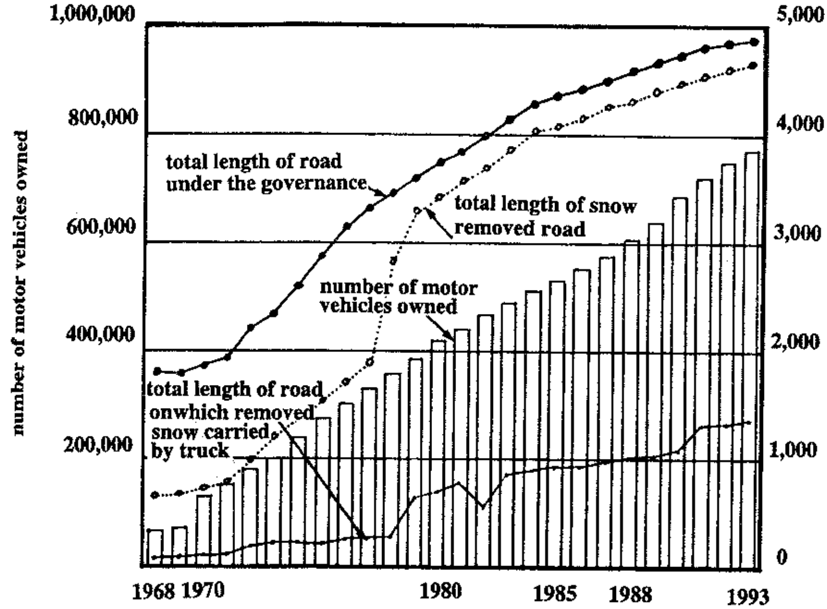
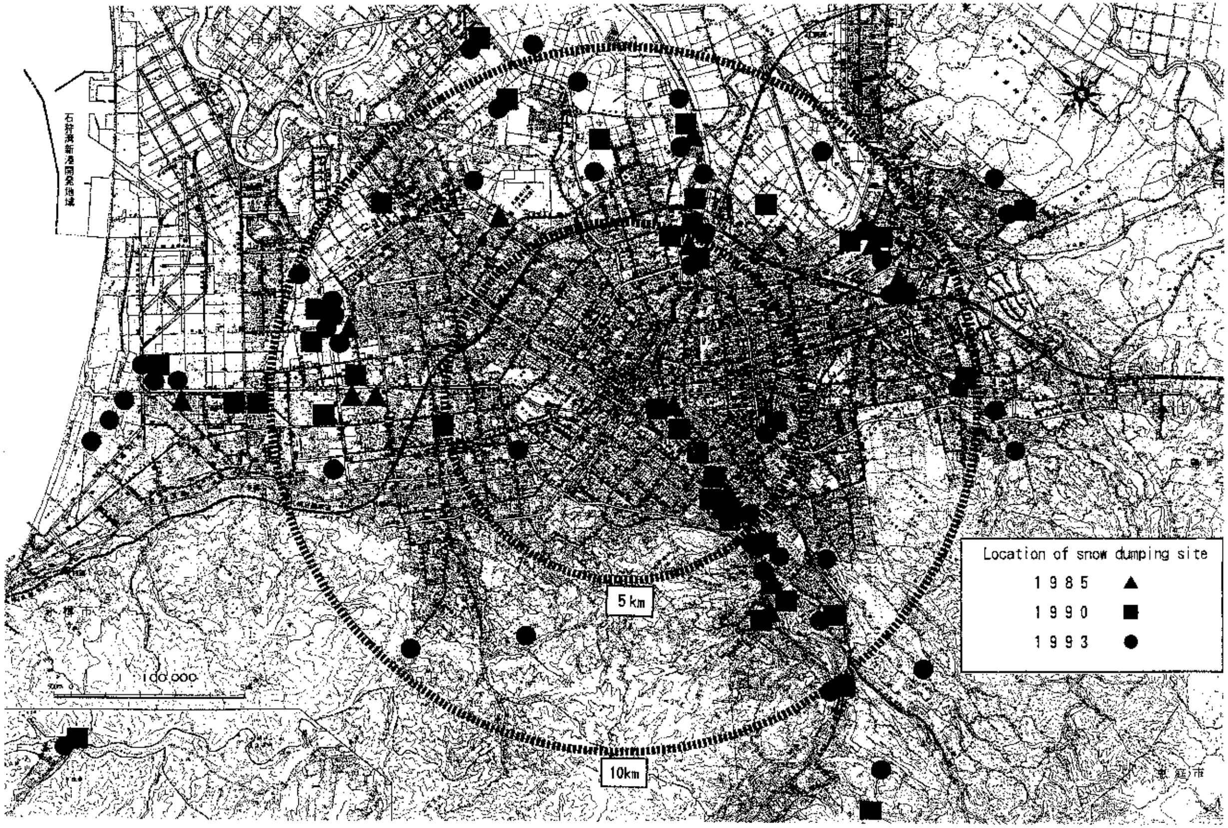


Fig. 4 The changes in the length of the roads which are cleared of snow transported by truck

The total amount of roughly 8,000,000 m^3 to 10,000,000 m^3 of snow, depending upon the amount of snowfall, is constantly removed in Sapporo per year. 30 % of the removed snow is dumped by the city and the rest dumped through voluntary activity of citizens and companies. Fig. 5 shows the location of the dumping sites in 1985 (▲), 1990 (■) and 1993 (●). In 1985, a considerable number of the sites were within a 5 km radius of the city center, including those along the Toyohira River, but these gradually decreased, and the number within a 5 km radius of the center was fewer in 1993. Whereas the number of sites in the city center has decreased, many sites have been established in city suburbs. Almost all the dumping sites were situated within a radius of 10 km of the city center in 1990, but by 1993 one third of them were outside the 10 km radius. Some of them even reached a 15 km radius.

The dumping sites are operated by the city as temporary facilities. Sapporo City Snow Removal Service Consignment Specification (Sapporo Road Maintenance Corporation, 1994) specifies the procedures of management of the snow dumping sites. The goal is mainly to set up signposts, such as guide signs and safety facilities like barricades and ropes, and to lay water-proof sheets in some places. The major maintenance work includes the following: (1) guiding cars and bulldozers; (2) keeping watch over people who bring garbage etc., into the site; (3) recording the number of incoming cars and the amount of snow disposed (by time and by type of vehicle) and (4) disposing the snow within the site and smashing packed snow. There is no environmental management in this work. Other cities in Japan carry out almost the same kind of dumping activity.

Fig. 5 The changes in location of dumping sites



3. POLLUTION OF THE ACCUMULATED SNOW IN SAPPORO

Generally in Japan, a snow removing vehicle is mobilized when the amount of snowfall is more than 10 cm deep. Usually the snow on the surface of the roads is pushed by a plow, a plate mounted in front of the snow removing vehicle, and dumped onto the roadside. As the height of the accumulated snow increases, snow removal is carried out by both rotary plow and truck, and snow on the roadside is transported to open space or dumping sites on the riverbanks. When the road is frozen, the deicing chemicals and sands or gravels are spread. These materials are also pushed onto the roadside by the plow.

Altogether, snow accumulated on the roadside is polluted by gaseous automobile emissions, oil and garbage from homes, as well as deicing chemicals and sands. All of these are also transported to the dumping sites by truck. The following is the results of the investigation of the accumulated snow in Sapporo and the pollution of the snow.

3.1 Investigation of the Composition of the Accumulated Snow

Fig. 6 shows the sites investigated in January, 1989. The concentration of suspended solids was calculated by deducting the value of the filtered sample from that of the unfiltered sample. Sites 1 and 2 were at the top of Mt. Teine (1,024 m), in the western part of the city, represent non-polluted areas. Sites 3 - 6 were located around a large scale laundry facility within a residential area. The purpose of the investigation at these points was to find the level of microscopic amounts of hazardous substances. Sites 7 and 8 were in the university experimental farm in the city center. They represent the area where there was less immediate pollution from residential wastes and road dusts. Site 9 was on the roadside of Nishi 5-chome Street which ran along the east side of Hokkaido University. Site 10 was 40 m from Nishi 5-chome Street, and Site 11 was 150 m from this road. Both sites were within the university campus where accumulated snow was collected to examine the effect of road dust, etc.

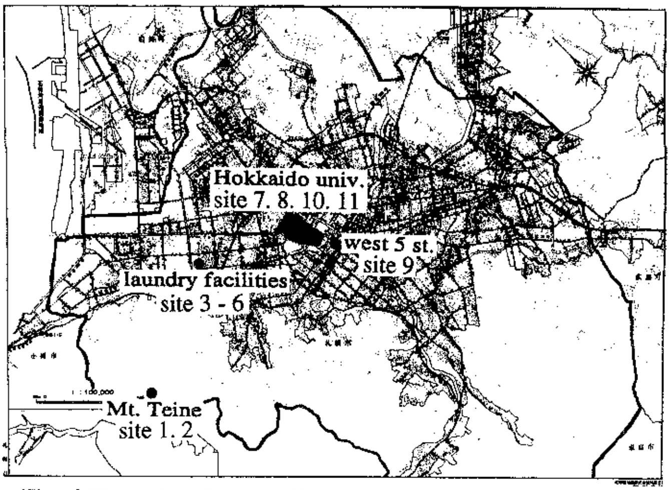


Fig. 6 The points for sampling accumulated snow in Sapporo

The snow temperature at the time it was collected was zero or under and the snow was of an average snow in winter. The density was low (0.1) at the top of Mt. Teine. It was a little bit higher (0.2 - 0.3) in the urban areas, such as the experimental farm and the vicinity of the large scale laundry facility. A lower layer of the accumulated snow showed a density of above 0.4. Table 2 summarizes the chemical analytical data of the properties of the accumulated snow. The analysis was conducted on the snow-melt water. The unit of analysis was the weight per 1 liter of snow-melt water.

(1) Suspended solids (SS), pH and Chloride ion (Cl^-)

The accumulated snow around the road had a high level of SS concentration and demonstrated a marked influence by road dust contamination. Among others, Nishi 5-chome Street had a higher level of SS concentration, over 1 g/l. A pH test of Sites 1 - 8, 10, 11, where less polluted and thus a lower buffering effect, indicated 4.5 - 5 (acidity). Thus, air pollution has had an effect. Some of the other sites indicated 8 (alkalinity) due to the contamination from solid wastes.

Generally the concentration of Cl^-, which is a representative component within water, was low, but figures were a little higher inside the university campus.

(2) Organic carbon (TOC) and Colony of bacteria

There was a high level of TOC as SS around roads. The rate of suspended matter was high. Almost all of it presumably comes from solid materials, such as road dust. The concentration of TOC at the top of Mt. Teine was about 0.5 mg/l, which represents normal conditions.

Low temperature heterotrophic bacteria have almost the same distributive pattern as TOC, which shows that the bacteria is related to organic pollution. No Colibacilli were found, so there is little concern regarding public health.

(3) Heavy metal components

Like TOC, heavy metal components tend to be SS, and their concentration varies with that of the SS. For example, Iron (Fe) on Nishi 5-chome Street had a high concentration of 9.61 mg/l when given an unfiltered sample (Fe_T) test, iron was also at a value below the detection limit when given a filtered sample (Fe_F) test. Thus, almost all components of heavy metal were suspended solids (Fe_{SS}). In addition, Zn was measured in rather high concentrations around roads. Therefore, Fe in the accumulated snow can be attributed to sand, and Zn seems to be contaminated with wastes.

(4) Nutrient salt

With the exception of Mt. Teine, the level of total nitrogen (T-N) and total phosphorus (T-P) at every sampling site was beyond the eutrophication level (N: 0.5 - 1.3, P: 0.01 - 0.09 mg/l).

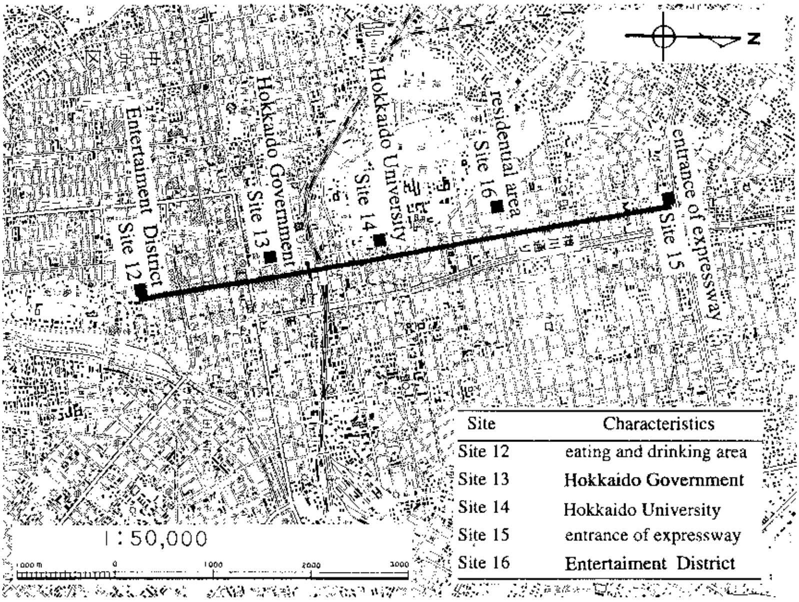
As for phosphorus, suspended P-P was characterized by its high concentration and high rate of 99 % in T-P 0.556 mg/l on Nishi 5-chome Street, where the accumulated snow was contaminated with road dust. There was a slight concentration difference in nitrogen among all sampling points. And there was a high rate of dissolved nitrogen. This seems to come from air and household wastes.

(5) Organochlorine compounds

Tetrachloroethylene was detected at the east side of the large scale laundry facility, and in the middle layer of the accumulated snow from the university experimental farm. Compared with the levels of Japan's environmental achievement for trichloroethylene and trychloroethane (10 μg/l), these compounds levels were very low at every site. But the fact that it was detected around the laundry facility means that there could be heavy pollution in the future. It is necessary to monitor the way the large scale laundry facility, the source of contamination, disposes of wastes and the route by which the accumulated snow is transported.

3.2 Dusts and Garbage within Accumulated Snow

The authors investigated the degree to which wastes were included within accumulated roadside snow in the city of Sapporo. The sites of investigation were shown in Fig. 7. The utilization of land in the city center is relatively well-divided: an amusement area, a shopping district, civic center, business center, university area and residential area (from south to north). Five representative sites were selected within each area and 3 m^3 of snow piled between the sidewalk and roadway were sampled. After melting at room temperature, we filtered the sample water through a 2 mm by 2 mm mesh sieve and classified the matter into 2 types: over 2 mm by 2 mm as dust and garbage, and less than 2 mm by 2 mm as suspended matter.



Site	Characteristics
Site 12	eating and drinking area
Site 13	Hokkaido Government
Site 14	Hokkaido University
Site 15	entrance of expressway
Site 16	Entertaiment District

Fig. 7 The investigation points for garbage within accumulated snow

Table 2 The results of the analysis on accumulated snow

No	site	snow layer	thickness of layer (cm)	air temp. (°c)	water temp. (°c)	density	SS (mg/l)	pH	Cl- (mg/l)	TOC(T) (mg/l)	TOC(F) (mg/l)	low temperature heterotrophic bacteria (n/ml)	coliform bacteria (n/ml)
1	top of Mt. Teine	surface layer	2 - 3	- 8.1	-3.8	0.10	1	4.5	4.0	0.4	0.4	4.0	0
2	top of Mt. Teine	lower layer	100	-8.1	-5.1		2	4.7	3.0	0.8	0.4	0.0	0
3	laundry facilities west	surface layer	2 - 3	2.3	-0.1	0.2	2	4.6	1.5	1.1	0.7	2.5	0
4	laundry facilities west	lower layer	90	2.3	-1.0	0.3	9	5.3	3.3	5.7	1.3	1.5	0
5	50m from laundry facili.	surface layer	2 - 3	2.3	0.0		9	4.6	19.7	1.3	0.7	8.0	0
6	laundry facilities east	surface layer	2 - 3	0.3	0.0	0.25	4	4.6	1.8	2.5	1.7	6.5	0
7	Hokkaido univ. expt. farm	surface layer	2 - 3	0.9	-0.5	0.19	3	4.4	23.3	2.6	2.1	3.0	0
8	Hokkaido univ. expt. farm	medium layer	30	0.9	-1.0	0.45	35	5.7	2.7	2.5	0.5	3.5	0
9	west 5 st.	roadside snow		0.0	-2.0	0.41	1045	8.5	17.0	78.2	2.6	4600.0	0
10	Hokkaido Univ. comp. ctr	surface layer	2 - 3	-2.5	-5.0	0.20	14	4.8	60.3	3.2	2.2	60.0	0
11	path ,Hokkaido Univ.	surface layer	2 - 3	-2.0	-4.3	0.24	25	4.5	34.0	4.3	2.3	170.0	0

No	Fe(T) (mg/l)	Fe(F) (mg/l)	Mn(T) (mg/l)	Zn(T) (mg/l)	Zn(F) (mg/l)	NO3-N (mg/l)	NO4-N (mg/l)	DN (mg/l)	T-N (mg/l)	DRP (mg/l)	DP (mg/l)	T-P (mg/l)	tetrachlorethylene (μg/l)	
1	ND 1	ND1	ND2	0.024	0.014	0.04	0.11	0.36	0.44	0.003	0.018	0.029	ND	
2	ND 1	ND 1	ND2	0.005	0.005	0.07	0.09	0.45	0.49	0.003	0.010	0.010	ND	
3	ND 1	ND 1	ND2	ND3	ND3	0.05	0.18	0.46	0.69	0.001	0.009	0.026	ND	
4	0.50	ND 1	ND2	0.005	ND3	0.12	0.18	0.63	0.67	0.001	0.017	0.029	ND	
5	ND 1	ND 1	ND2	0.009	ND3	0.08	0.16	0.61	1.13	0.000	0.010	0.015	ND	
6	0.02	ND 1	ND2	0.009	0.005	0.06	0.29	0.80	0.95	0.003	0.012	0.017	0.0269	
7	ND 1	ND 1	ND2	0.018	0.015	0.09	0.34	0.79	0.88	0.006	0.020	0.021	ND	
8	0.20	ND 1	0.24	ND3	ND3	0.08	0.29	0.51	0.56	0.000	0.002	0.023	0.0038	ND 1 < 0.02
9	9.61	ND 1	ND2	0.200	ND3	0.17	0.51	0.91	1.39	0.003	0.006	0.556	ND	ND 2 < 0.01
10	0.20	ND 1	ND2	0.050	0.040	0.13	0.57	1.08	1.31	0.012	0.012	0.061	ND	ND 3 < 0.005
11	0.25	ND 1	ND2	0.030	0.021	0.12	0.46	0.81	0.89	0.014	0.018	0.047	ND	Mn (F) : ND 2

(1) Content and composition of dusts and garbage in accumulated snow

The dusts and garbage contents per 1 m^3 are shown in Fig 8 in which sands (soil, gravel, asphalt, etc.) and others are separated. Generally, the dusts and garbage contents were within 0.5 - 1 kg/m^3, but at Site 13 (Photo 4) in the civic center, it was only 0.13 kg/m^3. There tends to be a high density of sands in streets of high traffic volume, such as at Sites 14 and 15. Sands (soil, gravel, asphalt, etc.) particles reached 95 % of the composition of dusts at the entrance of the expressway at Site 15 , which shows a high contribution of road dusts to the mixtures of sands. Conversely, the level of sands was significantly low at Site 16 in the residential area (Photo 5), which means the wastes chiefly come from household garbage.

Fig. 9 shows the weight of cans and cigarette butts at each sampling point. Cans were found more in the residential area than in the amusement area. This obviously reflects drivers' and walkers' bad habits of tossing them away, and poor management of a garbage-pickup point. Cigarette butts were found more around the civic center than in other areas due primarily to a higher level of pedestrian use. Table 3 shows the average amount of wastes within the accumulated snow per 1 m^3 at each point. Based on that result, we made a rough trial calculation of the total amount of garbage within the accumulated snow throughout the city of Sapporo. Assuming the population of the city now is 1,700,000, one citizen will drop one or two cigarette butts a day and one or two cans a day into accumulated snow. This value seems to be a little exaggerated, but it is evident that the amount of garbage within the accumulated snow is much more than we had expected.

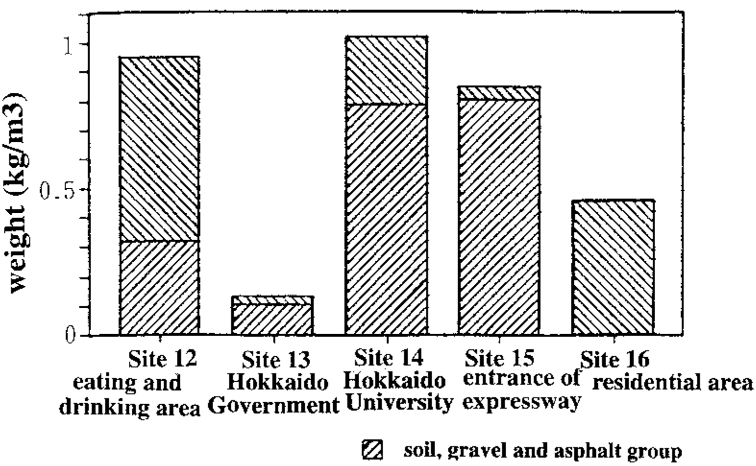


Fig. 8 The amount of garbage and sand and other small particles within accumulated snow per 1 m^3

Photo 4 . Garbage and dusts within accumulated snow near The Hokkaido Government (Site 13)

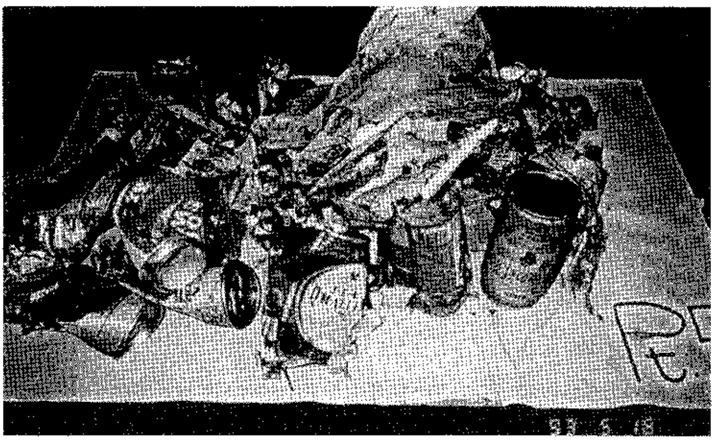


Photo 5 Garbage and dusts within accumulated snow in residential area (Site 16)

Table 3 The average value of the amount of garbage within accumulated snow per 1 m^3

items	content (n:number)
garbage	0.66 (kg/m^3)
soil,gravel and asphalt group	0.56 (kg/m^3)
soil,gravel and asphalt group other than soil	0.10 (kg/m^3)
cigarette butts	$1.8*10^3$ (kg/m^3) ($6.3n/m^3$)
cans	$37*10^3$ (kg/m^3) ($0.89n/m^3$)

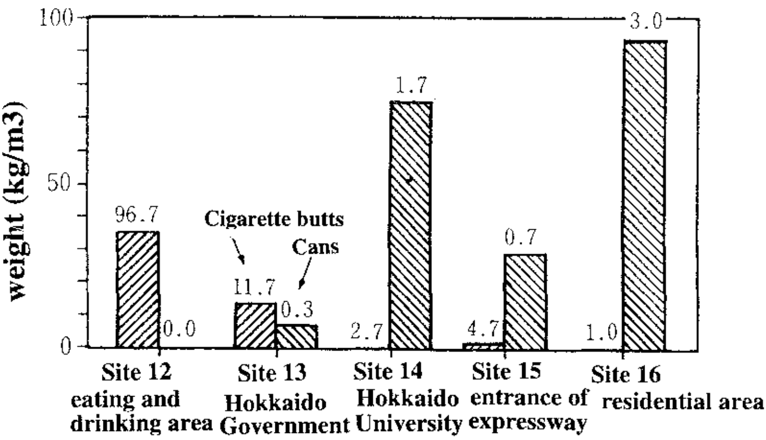


Fig. 9 The amount of cans and cigarette butts within accumulated snow per 1 m^3

(2) The chemical composition of the snow-melt water

Table 4 shows the results from the analysis of the quality of snow-melt water which was gathered for investigation. The common characteristic shown in this is that there was a high concentration of SS and the components of suspended particulates (TOC-TOCF, TN-DN, TP-DPm, etc.). The electrical conductivity was below 100μs/cm, which shows that the concentration of the general mineral elements (Cl^-, SO_4^{2-}, SiO_2) was like those found in an ordinary river. Therefore, regarding the garbage and waste products within accumulated snow, it should be noted that relatively large-size refuse causes problems while minute solid materials do not cause a big problem. However, since the concentration of nutrient salt is high in areas high in the restaurant districts and residential areas, we will have to keep watch over effluents from household garbage.

Table 4 The chemical components of snow-melt water

(mg/1)

		eating and drinking area Site 12	Hokkadio Gaverment Site 13	Hokkaido Univ Site 14	entrance of expressway Site 15	residential area Site 16
organic substances	TOC	14.6	15.8	19.0	25.1	21.5
	TO-CF	6.2	2.8	3.5	3.3	6.1
N	TN	2.64	1.14	0.99	1.32	3.09
	DN	1.13	0.65	0.56	0.4	1.01
	NO_3^--N	0.07	0.08	0.08	0.08	0.01以下
	NO_2^--N	0.02	0.02	0.02	0.01	0.01
	NH_4^+-N	0.80	0.48	0.32	0.29	0.78
P	TP	0.153	0.078	0.060	0.163	0.520
	DP	0.041	0.010	0.009	0.010	0.140
	TRP	0.134	0.145	0.032	0.089	0.141
	DRP	0.027	0.005	0.005	0.003	0.100
others	pH	7.7	7.5	7.3	7.1	6.8
	SS	180.5	164.7	96.6	185.3	161.6
	λ (μs/cm)	99.0	71.5	64.0	72.0	31.0
	Cl^-	7.2	6.9	4.8	6.4	4.1
	SO_4^{2-}	3.5	1.8	1.6	1.7	1.0
	4.3BX(mep)	0.062	0.050	0.047	0.044	0.017
	SiO_2	1.1	0.6	0.4	0.4	1.1

3.3 The analysis of the components of snow at a dumping site

The authors analyzed the components of snow sampled from a surface layer of accumulated snow at two dumping sites (Minami 19-jo bridge, Makomanai) of Sapporo. The Minami 19-jo bridge dumping site is exclusively used by public institutions, for the dumping of roadside snow. The Makomanai dumping site is for the general publics' use where citizens and companies dump snow.

The density of accumulated snow at a dumping site was as high as 0.53 because of the snow's settling force and due to being compacted by heavy machines, such as bulldozer, etc. The components of accumulated snow at the two dumping sites are shown in Table 5. The snow was composed of a rather high concentration of SS, which shows that the mixture of road dust is significant. At the Minami 19-jo dumping site, the value of TOC using an unfiltered sample was 139.2 mg/1, but there was a high concentration of 31.1 mg/1 when using a filtered sample. This shows that there is an intensive dumping of organic municipal wastes. As for the heavy metal concentration, Zn was as high as that in the accumulated snow around the streets.

Moreover, after the snow melts, there is a large amount of garbage left at a dumping site, so such garbage is carried away by several trucks every year.

Table 5 The results of the component analysis of snow at a dumping site

	Minami 19jyo-basi snow dumping site				Makomanai snow dumping site		
user	citizen				public works		
date	'89.1.31	'91.2.9	'91.2.9	'91.2.9	'89.1.31	'91.2.9	'91.2.9
snow sample	A	B	C	D	A	B	C
SS (mg/l)	192.0	136.4	278.0	865.1	365.0	393.1	3686.2
soil,gravel and asphalt etc. (mg/l) (b)		115.8	383.2	624.9		160.9	889.4
total(a)		252.2	661.3	1490.0		554.0	3575.6
(b)/(a)*100 (%)		45.9	58.0	41.9		29.0	24.9
TOC-T (mg/l)	139.2	15.0	25.0	90.5	21.4	40.7	360.0
TOC-F (mg/l)	31.1	0.9	1.4	1.0	0.4	0.6	1.7
TOC-SS (mg/l)	108.1	14.1	23.6	89.5	21.0	40.1	358.3

4. CONCLUSION

The purpose of this research is to describe the effects of a dumping site created through utilization of river space upon the river environment and to propose administrative measures to minimize such effects. To accomplish this purpose, we investigated the chemical composition of snow and found the following characteristics:

[Water quality]

■ The accumulated snow around the streets included a high concentration of SS.

- SS contained a considerable proportion of TOC and heavy metals.
- The concentration of T-N and T-P was beyond the level of eutrophication at almost all points.
- Some sample snow at a dumping site included an extremely high concentration of TOC, which shows that there was a concentration of organic municipal wastes.
- Colibacilli were not found, therefore there is less of a problem regarding public health.

[Dust]
- The amount of garbage mixed with accumulated snow and with snow at a dumping site is more than expected.
- There was a large amount of sand and other small particles around the streets, and a large amount of garbage in a residential area and an amusement area.

On the whole, the accumulated snow within the city was considerably polluted. As for the pollutants within the water, there was a high concentrations of suspended solids. Because the amounts of heavy metals and TOC correspond to the concentrations of SS, large amounts of them are estimated to be included in the suspended solid. This is because of the contamination of road dust. There is little concern over public health, but since the density of Nitrogen and Phosphorus was rather high, we are apprehensive that there may be a negative influence upon river water and underground water. Besides, the amount of garbage in accumulated snow was extremely high. Issues will be raised due to the negative effects on (1) the urban landscape after snow melts, (2) hygiene conditions by putrefaction of garbage, and (3) water quality by organic matter within municipal waste.

It is evident from the above-mentioned results that the installation of a dumping site on riverbanks is not appropriate because of the negative effects upon the water quality and other environmental elements. However, in a city such as Sapporo, where there is much snowfall and urbanization has advanced, it is hard to find an alternative site other than riverbanks. Moreover, there has been a great increase in citizens' expectations regarding snow dumping and the city government has accordingly increased the amount of snow removed and carried by trucks to dumping sites. This has made it even more difficult to eliminate the riverbank dumping sites and to secure other locations.

Therefore, from the point of view that the riverbank dumping sites will continue to be used, we will try to research methods which may reduce negative effects upon the environment. In the forthcoming research, we will address the following:

□ The degree of influence of polluted snow upon the river environment, including its water quality and the surrounding ecosystem.

□ The establishment of a dumping site management standard, which includes rules for protection of the environment.

□ The development of a simple SS removal system

□ Review of the garbage gathering and storage system (including moral aspects).

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