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Environmental Contamination and Toxicology

Lindane Transport in Fresh Water from Wetlands of Brittany to the Salt Water of The Bay of Mont St. Michel (France)

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Environmental consideration and protection has become very important in recent years in every avenue of man's endeavor. The pollution of soil and water in current agricultural practices where pesticides are used to control disease and insect pests pose the problem of ascertaining whether there are residues of pesticides, and if so, to what extent and do they constitute a hazard to the environment i.e. man, animal life, and plant life. (Winnett et al.1990, Miller et al. 1966)
Agriculture in the reclaimed wetlands on the north coast of Brittany (FRANCE) is unique. The flow of fresh water in the streams and drainage ditches is affected by tides. "Gates" are closed to prevent the salt water of the bay from entering the streams and irrigation canals of the wetlands during high tide. As the tides recede, the "gates" are opened permitting the fresh water to flow into the bay. The fresh waters carry, among other things, sediment and agricultural chemicals (eg. pesticide residues) resulting from agricultural practices in the polders adjacent to the Bay of Mont St. Michel. This project was designed to determine whether and how much of the pesticides used in the wetland agriculture are transported by water and sediment to the Bay of Mont St. Michel. Lindane, one of the pesticides of chosen for this project is commonly used in wetland agriculture of northern Brittany and represents the "insecticide" class of pesticides.

MATERIALS AND METHODS

The Bay of Mont St. Michel supports a large mussel and oyster industry as well as a fishing industry. The mussel beds are quite close to the outflow of the streams and irrigation ditches described above. Since mussels and oysters biomagnify pesticides dissolved in water, it is important to investigate the pesticide residue pollution possibilities in this area.
Samples of sediment and water were taken regularly from several representative sites in the bay (intercontinental) and in the streams and dotches of the wetland (continental)(see Figure 1 & 2) and extracted, cleaned up and analyzed as described in Gueuné and Winnett (1994)

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RESULTS AND DISCUSSION

All results of these analyses in the following tables and graphs were corrected for recovery. It should be noted that the sediment of each sampling site and logically the entire area of the wetland agriculture and intertidal regions normally have a titer of pesticides which is carried over from year to year (hence the pesticide levels in the winter months). These pesticide titers influence the content of the waters which flow over and into them. Most of these levels of pesticide are rather low during the winter months but they are there never–the–less.

It would seem that there are a number of factors which could and do influence the levels of pesticide in both the continental and intertidal sediment and waters:

The normal application dates are in April and May. The normal run–off of water from the treated lands due to irrigation and rainfall carry pesticides as well as sediment to the drainage ditches and streams thence to the intertidal areas of the bay.

The great storms which occurred in March, November, December and at other times during the year, disturb the sediment layer mostly in the intertidal region and to a degree, the bottom of the drainage ditches and streams (continental), causing the pesticides adsorbed on the sediment particles to dissolve in the water.

The temperature and salinity of the water influence the ability of the water to dissolve the pesticides from the sediment. Elevated temperatures encourage solvency while elevated salinity discourage solvency.

Since salinity in fresh water (continental) is relatively low in the winter (av. 3.5°/oo), temperature would be the controlling factor of numbers 1 and 2 above. The winter months (temp. av. 5.2° C.) would tend to keep the pesticide levels low. In the summer, the salinity and the temperature of the continental area, rises dramatically – 22°/oo and 19.3° C. respectively. The elevation of the temperature encourages the solubility of pesticides and the increased salinity, while it might tend to inhibit the solubility of pesticides might encourage the microorganisms to metabolize the parent pesticide i.e. Lindane.(Oddson et al. 1970)

The temperature of the intertidal region in the winter months, was on a par with those of the continental area and therefor the salinity would be the determining factor as far as the solubility of the pesticides is concerned. The salinity in the channel averaged 2.75°/oo in the winter and in the summer months averaged 19.88°/oo. The tributary has about the same salinity as the sea water, since the receding tidal water drains into the tributary.

Salinity in the intertidal areas (sea water) other than the tributary and the channel, in the spring, summer and fall averaged 31°/oo, varying between 29°/oo and 35°/oo. Since the change over the year was inconsequential, any variation in the pesticide level was not due to salinity variations but rather to temperature (av.18.7° C. varying between 13° C. – 25° C.).

An examination of the tables and graphs show that the fluctuations were indeed the result of applications, rain, storms and temperature. Lindane in the sediment of La Banche was certainly the result of lindane application to the agricultural area, with a peak of 11.75 parts per billion (ppb.) at the end of May (note – The sediment of La Banche, Les Planches and Le Guyoult were dredged out in May). This high was reflected in the water at 0.085 parts ppb. in La Banche, May, June and July, 0.05 ppb. in Le Cardequin, August, 0.044 ppb. in Les Planches and Le Guyoult Apr. and June respectively. The water of the Channel had residues of lindane of 0.087 ppb. in May and 0.043 ppb. in Sept. There seems to be a lag of 1 – 2 months before Lindane reached the Channel in the waters.

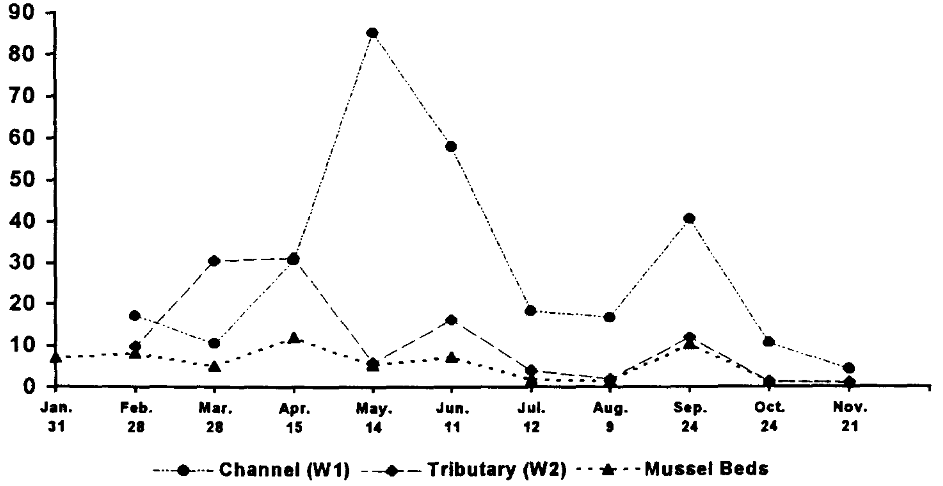
In addition, the residues of Lindane in the sediment of the intertidal region dropped off from a high of 3.4 ppb. in the fisheries and 2.4 ppb. in the channel in March to 2.0 ppb. in the fisheries and 1.3 ppb. in the channel. Also the channel had a level of 1.5 ppb. and the fisheries 1.25 ppb. in Sept. which rose to 3.75 ppb. and 3.3 ppb. in the month of Oct. respectively. The comparison of the continental highs in March, April and May, show very little correlation. Perhaps the temperature and salinity as well as the dredging of the continental streams and drainage ditches reduced the level of pesticides in the continental waters flowing into the intertidal area.
Intertidal Sediment The intertidal area shows an accumulation of pesticide in sediment consistent with the residues found in the continental areas with peaks which might indicate the effects of application as well as storm, temperature and salinity conditions.

The Channel is the main intertidal avenue of the continental water as it makes its way from the polders to the Bay absent the flooding of the entire intertidal region ie. fisheries, tributary and mussel beds at high tide.

All sampling from Intertidal Water sites showed relatively low titers of pesticide but there were highs and lows.

The results from this project have shown that there are residues of pesticides which have been transported from the polders to the Bay via the intertidal zone. Lindane, the pesticide which was measured, can be looked upon as a marker (Gueunè and Winnett 1994). which would seem to indicate that all agricultural chemicals ie. pesticides and fertilizers are in fact transported to the Bay via the intertidal zone. The pattern of rain has had a decided effect on the transport. Rain was scarce in the late spring and summer months and then returned in September and October. This was certainly a factor in the profile of residues both in the continental area and the Intertidal zone.

Lindane in Intertidal Water (ng/L)

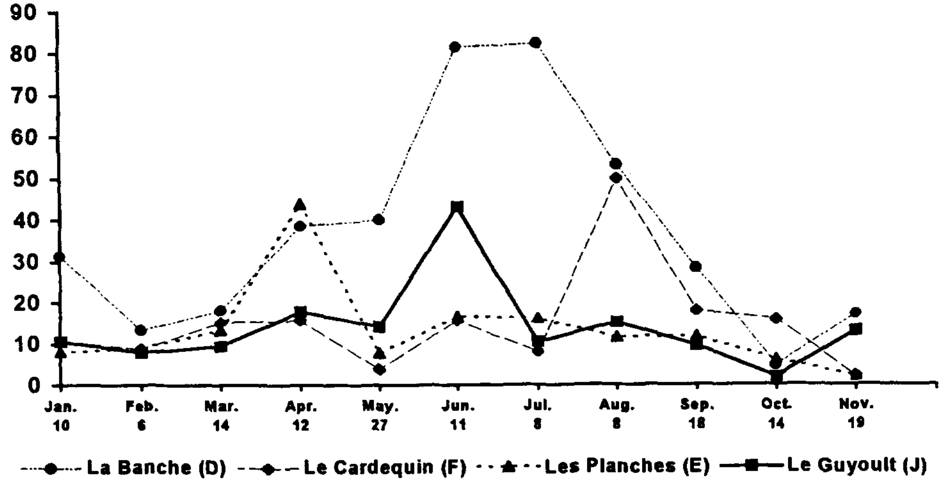


Lindane in Intertidal Water (ng/L) - 1991

Date	1/31	2/28	3/28	4/15	5/14	6/11	7/12	8/9	9/24	10/24	11/21
Station											
Channel (W1)	**NS**	**17.2**	**10.5**	**30.7**	**85.4**	**58.1**	**18.3**	**16.7**	**40.7**	**10.5**	**4.2**
SD	-	0.9	1.3	1.0	0.6	7.8	0.6	1.2	0.7	3.0	0.3
Tributary (W2)	**NS**	**9.7**	**30.6**	**31.2**	**5.8**	**16.2**	**3.9**	**1.9**	**11.9**	**1.3**	**1.2**
SD	-	1.2	1.1	1.4	0.1	1.4	0.3	0.8	2.3	0.2	0.1
Mussel Beds	**7.0**	**8.0**	**5.0**	**12.0**	**5.3**	**7.2**	**1.8**	**1.4**	**10.3**	**1.3**	**1.0**
SD	0.3	0.1	0.5	0.4	0.3	0.9	0.1	0.3	0.3	0.1	0.1

NS = No sample   SD = Standard deviation   Sensitivity = 5pg/5 microliters

Lindane in Continental Water (ng/L)

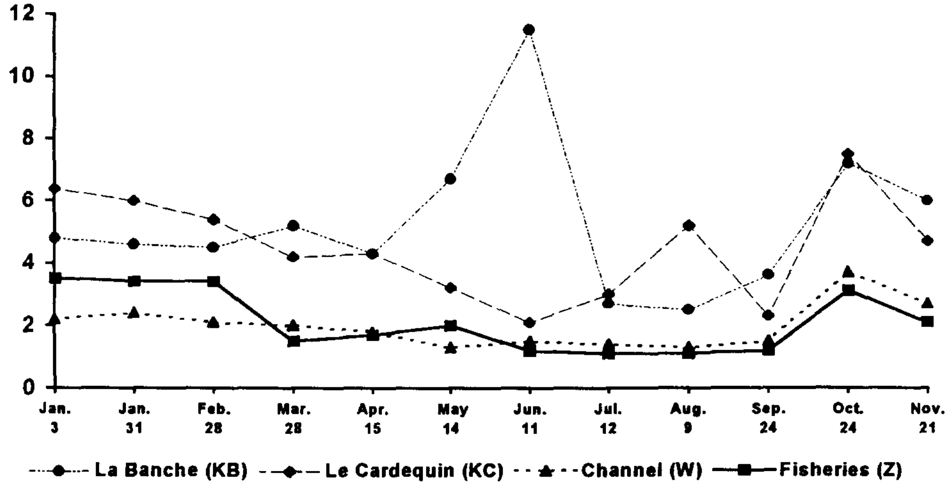


Lindane in Continental Water (ng/L) - 1991

Date / Station	1/10	2/6	3/14	4/12	5/27	6/20	7/8	8/8	9/18	10/14	11/19
La Banche (D)	**31.3**	**13.4**	**18.2**	**38.6**	**40.2**	**81.5**	**82.4**	**53.2**	**28.3**	**4.8**	**17.2**
SD	0.2	1.1	0.2	2.1	0.7	4.5	1.4	3.5	3.3	0.8	0.7
Le Cardequin (F)	**10.6**	**8.8**	**15.3**	**15.8**	**3.9**	**15.7**	**8.1**	**49.9**	**18.0**	**15.9**	**2.2**
SD	1.2	1.1	2.2	0.4	0.1	0.2	0.3	1.0	0.8	0.9	0.2
Les Planches (E)	**8.1**	**8.9**	**13.4**	**43.9**	**7.8**	**16.6**	**16.2**	**11.5**	**11.8**	**6.1**	**2.2**
SD	0.1	0.5	1.2	2.6	0.2	1.3	0.9	1.3	0.8	0.9	0.1
Le Guyoult (J)	**10.6**	**7.8**	**9.4**	**17.9**	**14.2**	**43.3**	**10.5**	**15.1**	**9.4**	**1.9**	**13.0**
SD	1.1	1.2	1.3	1.1	0.4	0.6	1.5	0.3	2.1	0.2	0.7

SD = Standard deviation Sensitivity = 5pg/5 microliters

Lindane in Sediment (ug/kg)



Lindane in Sediment (ug/kg) - 1991

Date / Station	1/3	1/31	2/28	3/2	4/15	5/14	6/11	7/12	8/9	9/24	10/24	11/21
La Banche (KB)	**4.8**	**4.6**	**4.5**	**5.2**	**4.3**	**6.7**	**11.5**	**2.7**	**2.5**	**3.6**	**7.2**	**6.0**
SD	0.3	0.3	0.3	0.2	0.1	0.2	1.8	0.2	0.1	0.2	0.2	0.2
Le Cardequin (KC)	**6.4**	**6.0**	**5.4**	**4.2**	**4.3**	**3.2**	**2.1**	**3.0**	**5.2**	**2.3**	**7.5**	**4.7**
SD	0.3	0.3	0.3	0.2	0.3	0.2	0.4	0.1	0.3	0.4	0.5	0.6
Channel (W)	**2.2**	**2.4**	**2.1**	**2.0**	**1.8**	**1.3**	**1.5**	**1.4**	**1.3**	**1.5**	**3.7**	**2.7**
SD	0.2	0.3	0.2	0.3	0.1	0.1	0.3	0.1	0.2	0.2	0.2	0.3
Fisheries (Z)	**3.5**	**3.4**	**3.4**	**1.5**	**1.7**	**2.0**	**1.2**	**1.1**	**1.1**	**1.2**	**3.1**	**2.1**
SD	0.2	0.2	0.2	0.1	0.2	0.1	0.3	0.1	0.1	0.2	0.2	0.2

SD = Standard deviation   Sensitivity = 5pg/5 microliters

Any good project or thesis is characterized by the fact that it raises more questions than it answers. For this work to be of any value, it must be continued since aspects such as the vagaries of weather ie. temperature, rainfall and other growth conditions vary from year to year. There are certain questions which were raised by this project such as: what is the role of microorganisms i.e. algae as far as adsorption, absorption, metabolism and transport of pesticide products.... the role of marine animals such as mussels; are they rendered inedible, do they cleanse the water and thus reduce the pesticide content; Are other animals affected ie. fish, oysters and other animals higher in the food chain etc. Future work must include projects which will be designed to address these questions.

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