mined from these unknowns (Table 4). Phthalic acid is rapidly decarboxylated (Table 3), we postulate, to form either the 1,2-dihydroxy benzene (catechol) or benzene. We believe the hydroxylated compound is the most probable product. Meikle (1972) indicated that when the carboxyl group is attached directly to the aromatic ring, the most common microbial attack on the molecule is via the oxidation decarboxylation pathway. Aerobic and anaerobic investigation of ^{14}C-*n*-butyl phthalate and ^{14}C-phthalic acid (both carboxyl-labelled) tend to support this biodegradation pathway (Table 3). TLC-autoradiograms of ^{14}C-BP hydrosoil extracts reveal the disappearance of the monoester concomitant with the appearance of trace amounts of material at R_f 0.09 (phthalic acid) and loss of radioactivity from the TLC plates. Autoradiograms of phthalic acid extracts showed no detectable degradation products, and furthermore, after 7 days incubation the hydrosoil extract contained less than 5% of the radioactivity that was recovered from the autoclave-killed control ether-extract. Radiorespirometry data showed rapid decarboxylation of phthalic acid in hydrosoil (Table 3). For example, we recovered 40.1 and 75.8% of the ^{14}C-phthalic acid radioactivity as trapped $^{14}CO_2$ after incubation in hydrosoil for 3 and 7 days, respectively. Similarly, in hydrosoil, nearly 33% of the radioactivity of the monoester ^{14}C-BP appeared as $^{14}CO_2$ in 3 days and nearly twice that amount in the next 4 days. In general, the disappearance of radioactivity recovered from TLC-plates closely paralleled the recovery of $^{14}CO_2$ trapped in the respirometer samples. No radioactivity was detected in the OV-225 Chromosorb W column from either ^{14}C-phthalic acid or ^{14}C-BP samples.

There is extensive literature on the microbial destruction of the aromatic nucleus, leading to the ultimate utilization of the C-fragment by microorganisms (Evans 1963; Gibson 1968, 1972). Unfortunately, we were unable to obtain substantial evidence to suggest ring cleavage after ester hydrolysis because the phthalic acid moiety was only ^{14}C-carbonyl labelled.

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TABLE 3. Aerobic degradation of ^{14}C-di-*n*-butyl phthalate, ^{14}C-di-2-ethylhexyl phthalate, ^{14}C-mono-*n*-butyl phthalate, and ^{14}C-phthalic acid by freshwater hydrosoil in a radiorespirometer.

^{14}C-labelled compound	$^{14}CO_2$ evolved (total dpm × 10^3)[a]					Total dpm	
	3 days	7 days	14 days	21 days	28 days	Recovered as $^{14}CO_2$	Introduced as ^{14}C-compound[b]
di-*n*-butyl phthalate	ND	24.3	8.6	5.0	1.6	39.2	50.0
di-2-ethylhexyl phthalate	ND	2.1	12.0	8.5	7.6	30.2	50.0
mono-*n*-butyl phthalate	12.4	23.0	ND	ND	ND	35.4	38.0
phthalic acid	97.3	181.1	ND	ND	ND	278.4	268.6
Control[c]	0	0	0	0	0	0	0

[a] $^{14}CO_2$ trapped in monoethanol amine:ethylene glycol. Data represent average of duplicate samples. ND = not done.
[b] Approximate value ± 5.0%.
[c] All heat-killed and NaN_3 controls showed < 0.1% total dpm introduced as $^{14}CO_2$.

DECARBOXYLATION IN HYDROSOIL

We attributed the rapid loss of radioactivity from the hydrosoils to biodegradation of the labelled phthalates during incubation (Table 3). We speculate that the ^{14}C-labelled portion of the phthalate molecule, the carbonyl group, is exposed to further degradation after initial hydrolysis of the ester-linkage. Subsequently, the labelled carbon is removed from the mono-phthalate (or phthalic acid, salicylate, or benzoate) moiety in the form of $^{14}CO_2$ by decarboxylation. To test this hypothesis, we inoculated ^{14}C-*n*-butyl phthalate (BP) and ^{14}C-phthalic acid into hydrosoils and incubated them in a radiorespirometer. During aerobic incubation, we detected no ^{14}C-volatile compounds other than $^{14}CO_2$ escaping from the hydrosoil into the effluent gas and no radioactivity in the toluene extract from the OV-225 column.

Recovery of radioactivity from the CO_2-trapping solution closely paralleled the disappearance of ^{14}C-labelled material from TLC-autoradiograms of both ^{14}C-DBP and ^{14}C-DEHP (Table 3). Only trace amounts of $^{14}CO_2$ activity were recovered from heat-killed and NaN_3 controls. We interpret these data to indicate that the ^{14}C-labelled material in the monoethanol amine solution is carbon-14 labelled carbon dioxide in the form of ^{14}C-carbamate; the evolution of $^{14}CO_2$ is due to the direct enzymic activity of the hydrosoil microflora on the ^{14}C-phthalates.

TABLE 4. R_f values of phthalic acid esters and potential degradation products.

Compound	R_f value[a,b]
n-butyl salicylate	0.90
Di-2-ethylhexyl phthalate	0.85
Di-*n*-butyl phthalate	0.81
Benzoic acid	0.60
Salicylic acid	0.51
Mono-2-ethylhexyl phthalate	0.36
Mono-*n*-butyl phthalate	0.33
p-hydroxybenzoic acid	0.20
3-hydroxyphthalic acid	0.16
Phthalic acid	0.09

[a] Solvent system = petroleum ether:diethyl ether:acetic acid, 77:20:3 (vol/vol/vol) TLC plates were developed 3 times.
[b] Values are the mean of five replicates.

PAE DEGRADATION PATHWAY

We propose a pathway for the biodegradation of DBP and DEHP by microflora in freshwater hydrosoil. The proposed scheme is predicated on TLC-autoradiography evidence. Under either aerobic or anaerobic conditions, the diesters are initially hydrolyzed at the ester linkage to form the phthalic acid half-ester and the corresponding alcohol. We believe this monoester is subsequently degraded, primarily to phthalic acid, by continuous esterase activity in the hydrosoil. We suspect that the exposed carboxyl group of the monoester undergoes decarboxylation (either oxidative or reductive) to form the benzene or salicylate derivatives. The R_f values of authentic standards of benzoates and salicylates, however, exceed the R_f values of 0.25 and 0.15 deter-

TABLE 2. Effect of incubation on the recovery of di-*n*-butyl phthalate from a freshwater hydrosoil.

Radioactive compound	R_f value[b]	% Recovered radioactive compound after day(s) incubation[a] 1	5	7	14	30
Aerobic Incubation						
Di-*n*-butyl phthalate	0.82	46.3±5.7	85.3±2.8	70.0±2.1	74.0±2.1	76.0±6.5
Mono-*n*-butyl phthalate	0.33	46.3±5.0	7.0±2.1	26.0±2.0	22.0±1.5	18.6±6.1
Unknown I	0.25	2.3±0.3	Trace[d]	0	0	0
Unknown II	0.15	0.1±0.01	0	0	0	0
Phthalic acid	0.09	0.9±0.06	2.3±1.2	3.0±0.5	2.3±0.6	3.6±1.3
Origin	0.00	2.3±0.05	3.3±0.3	1.0±0.05	1.0±0.01	1.0±0.01
% Recovery DBP compared to control[c] at day(s)		95.0	2.9	5.4	7.9	2.7
Anaerobic Incubation						
Di-*n*-butyl phthalate	0.82	68.3±10.0	29.6±8.9	29.0±8.1	5.0±1.5	37.6±12.1
Mono-*n*-butyl phthalate	0.33	30.7± 5.0	45.3±4.5	63.0±9.0	85.6±5.0	16.9± 6.5
Unknown I	0.25	T[d]	4.3±0.3	1.3±0.3	1.0±0.03	0
Phthalic acid	0.09	0.5± 0.01	16.3±4.6	4.6±3.2	6.3±2.7	35.0±11.7
Origin	0.00	T	4.6±1.4	T	T	9.0± 2.5
% Recovery DBP compared to control[c] at day(s)		100.0	69.1	58.5	39.1	2.0

[a]TLC-autoradiographic analysis; data represent mean value of triplicate samples ($\bar{x}$ = ±SE).
[b]Solvent system = petroleum ether:diethyl ether:acetic acid (77:20:3 vol/vol/vol).
[c]Autoclave-killed control:aerobic 158,109 ± 3,165 dpm and anaerobic 166,018 ± 14,758 dpm ($\bar{x}$ ± SE).
[d]Trace = 0.01% total recovered radioactivity.

TABLE 1. Biodegradation of ^{14}C-di-*n*-butyl phthalate and ^{14}C-di-2-ethylhexyl phthalate in freshwater hydrosoil.

Incubation (*days*)	Percent recovery of radioactivity from hydrosoil	
	Aerobic	Anaerobic
^{14}C-di-n-butyl phthalate		
1	95[b]	100[b]
5	3[c]	69[c]
7	5[c]	59[c]
14	8[c]	39[c]
30	3[c]	2[c]
Heat-killed control[d]	100	100
^{14}C-di-2-ethylhexyl phthalate[a,e]		
7	100[b]	100[b]
14	53[c]	100[b]
30	41[c]	100[b]
Heat-killed control[d]	100	100

[a]Data represent the mean value of triplicate samples. Precision = 85 ± 5%. Values rounded to nearest 1.0.

[b]No significant difference existed between control ($P < 0.05$, Fisher's "*t*").

[c]Significant difference between control ($P < 0.05$, Fisher's "*t*").

[d]30-day incubation.

[e]Degradation products were 2% of total radioactivity recovered.

under anaerobic conditions, whereas only 3% of the extractable labelled DBP and degradation products remained after 5 days of aerobic incubation. Degradation in anaerobic hydrosoils did not reach the aerobic level until the 30-day sampling. Ester hydrolysis required twice as much time in anaerobic as in aerobic hydrosoil, and decarboxylation time was about 6 times longer under anaerobic conditions. DEHP was completely resistant to microbial attack under anaerobic conditions. After 30 days, we observed no significant loss of ^{14}C-DEHP activity in hydrosoils overlayed with nitrogen (Table 1).

IDENTIFICATION OF DEGRADATION PRODUCTS

In TLC-autoradiography analyses of the ^{14}C-DBP and ^{14}C-DEHP hydrosoil extracts we repeatedly found radioactivity in DBP extracts at R_f 0.82, 0.33, 0.25, 0.15, 0.09, and 0.00 (Table 2). The spots at R_f 0.82, 0.33, and 0.09 (Table 4), when cochromatographed with nonradio-labelled authentic standards, were similar to the spots of di-*n*-butyl phthalate, *n*-butyl phthalate, and phthalic acid, respectively. The spots at R_f 0.25, 0.15, and 0.00 did not correspond to known degradation products (Table 4). Quantitation of the radioactivity at each R_f value by liquid scintillation spectrometry indicated that the major degradation product of the 1-day sample was the monoester (46.3%). Small amounts of compounds more polar than the monoester (6% of the total recovered radioactivity) were at R_f 0.25, 0.09, and 0.00. R_f 0.09 corresponded to phthalic acid; R_f 0.25 and 0.00 were unidentified compounds.

Significantly, recovery of radioactive material showed that samples incubated for 1 day contained 95% of the total radioactivity found in the control. This recovery decreased in the 5-, 7-, 14-, and 30-day samples. In comparison with the control, only 2.9–7.9% of the radioactivity introduced into these samples was recovered (Table 2). Qualitative analyses of these extracts by TLC-autoradiography revealed the parent diester, the monoester, phthalic acid, and a trace amount of an unknown or unknowns at the origin in an approximate ratio of 76:18:3:1% (Table 2).

The slower rate of PAE degradation under anaerobic than under aerobic conditions is clearly reflected in the type and quantities of the radioactive components extracted from hydrosoils after various incubation intervals (Table 1, 2). At least four compounds were detected in anaerobic DBP samples: the monoester, phthalic acid, and two unknowns at R_f 0.25 and 0.00. The compound or compounds at R_f 0.15 was not seen in any of the autoradiograms taken from anaerobic extracts. Although *n*-butyl phthalate was the major degradation product in either the aerobic or anaerobic samples after 1 day of incubation, the degradation rate was more than 1.5 times faster under aerobic conditions (32% vs. 50%). Qualitative comparison of aerobic with anaerobic phthalate degradation after the first 24-h incubation period is at best tenuous because of the rapid loss of radioactivity from the samples. We did, however, observe an increase in the monoester after long incubation and an apparent lack of accumulation of the more polar degradation products in anaerobic samples (Table 2).

TLC-autoradiographic analysis of aerobic DEHP extracts revealed radioactive spots at R_f 0.85 and 0.36. Cochromatographic data with authentic standards suggest that the products were di-2-ethylhexyl phthalate and the monoester, 2-ethylhexyl phthalate. Liquid scintillation quantitation showed only 2% of the total recovered radioactivity as the monoester. We found no other compound in the aerobic extracts. After 30 days, hydrosoils incubated anaerobically showed no detectable DEHP degradation.

(BBL). All hydrosoil samples contained 5% organic carbon (dry weight) (American Public Health Association 1971). Ten grams (wet weight) of hydrosoil were placed into a 50-ml Delong flask and covered with 20 ml of pond water. The flask content was then inoculated with 100 μl of acetone containing the ^{14}C-labelled phthalate. Cultures were adjusted to contain about 1 mg/liter labelled phthalate. After inoculation, the aerobic groups were incubated in a water bath rotary shaker (180 rpm, 1 in orbit) and the anaerobic groups were placed in an anaerobic jar (Torsion Co.), evacuated under vacuum, and overlayed with nitrogen. All samples were incubated at 22 C. We tested for spontaneous degradation (abiotic) of the phthalates by including an autoclave-killed control. The control sample was autoclaved at 15 lb pressure and 121 C for 20 min. We added 250 mg/liter sodium azide to some hydrosoil samples as a chemical means of inhibiting microbial activity (Kaufman et al. 1968). Hydrosoil was maintained under aerobic or anaerobic conditions and sampled in triplicate at 1-, 5-, 7-, and 30-day intervals. Controls consisted of acetone and autoclave-killed hydrosoil. All samples were extracted on the day of collection. Each hydrosoil sample was initially acidified to pH 1-2 with concentrated H_3PO_4 and extracted 3 times with an equal volume of diethyl ether. The ether extracts were centrifuged for 10 min at 10,000 $\times$ *g* to remove particulate matter and break emulsions, combined, dried over anhydrous Na_2SO_4, and carefully evaporated to about 1 ml at room temperature under a hood. Extraction efficiency of the phthalates from hydrosoil was routinely 85 $\pm$ 5%; all data are based on this accuracy value. Autoradiography of thin-layer chromatograms indicate both ^{14}C–DBP and ^{14}C–DEHP were 99+% pure.

Chromatography–Autoradiography

The ether extract was spotted by means of a Camag Linomat® automatic TLC spotter on 0.2-mm precoated silica gel thin-layer chromatography plates (Brinkman, EM Reagents, Silica Gel, F-254) containing a fluorescent indicator. The TLC plates were developed 3 times in petroleum ether:diethyl ether:acetic acid (77:20:3) (vol/vol/vol) (Stalling et al. 1973). We used no-screen medical X-ray film to visualize radioactive products by autoradiography and shortwave ultraviolet light (2537Å) to detect nonlabelled standards and controls. The quantity of each radio-labelled material separated on the chromatogram was determined by scraping silica gel from the specific radioactive R_f area into a scintillation vial containing 15 ml of toluene:fluor (Fluoralloy®, Beckman Instrument Co.) and then counting the mixture with a Beckman 200-L liquid scintillation counter set for ^{14}C-β-particle energy spectrum. Results were corrected for quench and background radiation.

Radiospirometry

We constructed a radiospirometer to detect possible $^{14}CO_2$ evolution from the ^{14}C-phthalate hydrosoil sample during incubation. Hydrosoils containing the two ^{14}C-diesters were sampled at 7-, 14-, 21-, and 28-day intervals for $^{14}CO_2$ production. Controls consisted of both autoclave-killed and NaN_3 samples. Air was passed at a flow rate of 5 ml/min into the experimental chamber after being scrubbed with 2 N NaOH to remove CO_2. The effluent gas from the incubation chamber was first passed through a 50.4- $\times$ 6.35-mm column containing OV-225 coated Chromosorb W HP and finally bubbled through a monoethanol amine:ethylene glycol-CO_2 (3:7 vol/vol) trapping solution. The $^{14}CO_2$ was trapped as a carbamate. To investigate the efficacy of this system, we evaporated ^{14}C-labelled phthalic acid, DBP, DEHP, and BP in a small flask, connected it to the respirometer, and gently warmed the flask to vaporize the materials. We found only trace amounts of radioactivity in the CO_2-trapping solution. The major portion of the radioactivity recovered was confined to the Chromosorb W column. Triplicate, 1-ml samples of the $^{14}CO_2$-mono-ethanol amine solution were added to 10 ml of a dioxane-fluor mixture composed of 4 g of 2,5-diphenyloxazole (PPO), 200 mg of 1,4 *bis*-2-(4-methyl-5-phenyloxyazolyl)-benzene (POPOP), 100 ml of methanol, and 60 g of naphthalene in 1 liter of dioxane. Scintillation samples were counted with the Beckman 200-L liquid scintillation system and corrected for quench and background radiation.

Statistical Inference

Mean comparisons were made according to Fisher's "*t*" test; significance was taken at $P < 0.05$. All data represent the mean value of samples removed from triplicate incubation vessels ($\bar{x} \pm$ SE).

Results and Discussion

Freshwater hydrosoil degraded both ^{14}C-DBP and ^{14}C-DEHP (Tables 1, 2, 3). Since autoclave-killed or NaN_3 controls did not significantly degrade either ester, we attributed the degradation of the two phalates to the enzymic action of microorganisms indigenous to freshwater hydrosoil.

We found marked differences between the conditions and rates of biodegradation of the two esters. Forty-Six percent of the radio-labelled DBP in hydrosoil (Table 2) was degraded aerobically to mono-*n*-butyl phthalate within 24 h and nearly 98% (Table 1) of all radioactivity disappeared after 5 days. Under the same conditions, nearly 14 days were required for 53% of the DEHP-labelled material to disappear (Table 2).

Anaerobiosis slowed biodegradation of both esters. Although nearly 98% of the radio-labelled DBP disappeared during 30 days of incubation in the hydrosoil, the retarding influence of anaerobiosis was evident. Nearly 70% of the DBP radioactivity remained after 5 days of incubation

se produit à un rythme ralenti d'un sixième, alors que nous n'avons pas détecté de dégradation de DEHP. La chromatographie en couche mince, de même que la radiorespiratométrie, suggèrent que les esters, après hydrolyse initiale, subissent une décarboxylation, probablement vers la molécule 1,2-dihydroxybenzène.

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REPORTS of phthalic acid esters (PAEs) in soil (Ogner and Schnitzer 1970), water (Corcoran 1973; Hites 1973), and fish (Mayer et al. 1972) have appeared in the recent literature. Mathur (1974) has only recently reviewed the topic of phthalate esters in the environment. During 1972, an estimated 1 billion pounds of 20 different phthalates were manufactured in the United States (Hall 1971). Although PAEs, the esters of benzene ortho dicarboxylic acid, have a broad spectrum of uses ranging from defoaming agents to perfume vehicles in cosmetic production (U.S. Tariff Commission 1971), they are utilized chiefly as plasticizers with the poly (vinyl chloride) polymers (PVCs). Used in conjunction with PVCs, plasticizers impart flexibility, workability, and extensibility to the product (Graham 1973). In as much as PAE plasticizers have a many faceted market in automotive, construction, clothing, home furnishing, medical, and packaging industries (U.S. Tariff Commission 1971), their appearance in aquatic organisms and habitats seems inevitable. Even though PAE residues are apparently ubiquitous in the environment, the acute and chronic effect on man and wildlife remains essentially unknown — "an etiology in search of a disease" (Tepper 1973). Fragmentary evidence suggests potential deleterious effects on freshwater biota. Sanders et al. (1973) and Mayer and Sanders (1972) reported reproductive inhibition and bioaccumulation in the filter-feeding cladoceran *Daphnia magna*. Metcalf et al. (1973) also found rapid accumulation of phthalates in a variety of plants and animals in a model ecosystem. The fate of PAEs in the aquatic environment remains largely a mystery. Saeger and Tucker (1973) demonstrated that all PAEs tested underwent complete aerobic degradation, at rates comparable with those of a readily degradable linear alkyl benzene sulfonate, in the presence of activated sewage sludge and river water. Unfortunately, no data are available concerning degradation under the anaerobic conditions that frequently attend hydrosoils in the natural environment. A number of questions concerning the ultimate fate of PAEs remain unanswered. Do PAEs rapidly undergo complete biodegradation in the aquatic environment to harmless elemental fragments or are they resistant to microbial attack? Are the current PAE residues a reflection of persistency or an equilibrium between input and natural decomposer activity?

In this investigation, we report on the biodegradation of two widely used plasticizers, di-2-ethylhexyl phthalate (DEHP) and di-*n*-butyl phthalate (DBP) by unidentified aerobic and anaerobic microorganisms found in hydrosoil of freshwater ponds. The studies were performed in the laboratory under aerobic and anaerobic conditions, with ^{14}C-labelled phthalic acid esters. The microbial degradation of phthalates was determined by thin-layer chromatography–autoradiography and measurement of $^{14}CO_2$ released from labelled phthalates.

Materials and Methods

CHEMICALS

^{14}C-carbonyl-labelled di-*n*-butyl phthalate (1.53 mCi/mM). di-2-ethylhexyl phthalate (1.64 mCi/mM) and phthalic acid (2.74 mCi/mM) were purchased from Mallinckrodt Co. Standards of DBP and DEHP were obtained from Monsanto Company. Chemicals listed in Table 4 were purchased from Chem Service or Eastman Kodak Chemical Co. The ^{14}C-*n*-butyl phthalate (monoester, BP) was synthesized from ^{14}C-DBP by *Bacillus subtilis* (Fish-Pesticide Research Laboratory Collection). Acetone was used as the solvent carrier for all compounds investigated (<0.01% vol/vol). Plate counts were made of control samples containing 0.1% (vol/vol) redistilled, analytical grade acetone at 1-, 7-, and 30-day intervals. We found no evidence that acetone influenced the viability of the microflora in hydrosoil or induced any radical pH changes in the cultures during incubation.

CULTURING AND EXTRACTION METHODS

Hydrosoil samples were taken from 0.04- and 0.10-ha freshwater ponds located at the Fish-Pesticide Research Laboratory. We used a core-type sampling device (Holz et al. 1972) to collect pond bottom material along the shoreline at a water depth of about 1 m. We removed the hydrosoil to a depth of 5 cm in the core sample at the mud–water interface and screened it through a 40-mesh wire sieve to eliminate macroinvertebrates. Plate counts of the hydrosoil, incubated both aerobically and anaerobically at 22 C, showed an average population of 5×10^6 viable organisms per milliliter on brain–heart infusion agar

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Biodegradation of Di-*n*-Butyl Phthalate and Di-2-Ethylhexyl Phthalate in Freshwater Hydrosoil[1]

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Johnson, B. T., and W. Lulves. 1975. Biodegradation of di-*n*-butyl phthalate and di-2-ethylhexyl phthalate in freshwater hydrosoil. J. Fish. Res. Board Can. 32: 333–339.

The phthalic acid esters di-2-ethylhexyl phthalate (DEHP) and di-*n*-butyl phthalate (DBP) which are used as plasticizers and recovered in routine chemical analysis of freshwater fish, were incorporated into freshwater hydrosoil in the laboratory. Samples containing about 1 mg/liter of these two esters, ^{14}C (carbonyl) labelled, were incubated aerobically and anaerobically for 1, 5, 7, 14, and 30 days. Differences in the rates and conditions of degradation of the two esters were marked. Under aerobiosis, 53% of the radio-labelled DBP was degraded within 24 h, and 98% within 5 days; DEHP, in contrast, was only 50% degraded after 14 days. Under anaerobiosis degradation of both esters was retarded. DBP was degraded only one-sixth as fast in hydrosoil overlayed with nitrogen whereas degradation of DEHP was not detected. Our evidence from both thin-layer chromatography and radiorespirometry suggests that the esters undergo decarboxylation after initial hydrolysis, probably to the 1,2-dihydroxybenzene molecule.

Johnson, B. T., and W. Lulves. 1975. Biodegradation of di-*n*-butyl phthalate and di-2-ethylhexyl phthalate in freshwater hydrosoil. J. Fish. Res. Board Can. 32: 333–339.

Les esters di-2-éthylhéxyl phthalate (DEHP) et di-*n*-butylphthalate (DBP) de l'acide phthalique, utilisés comme plastifiants et récupérés lors d'analyses chimiques routinières de poissons d'eau douce, ont été incorporés à un hydrosol d'eau douce au laboratoire. Des échantillons contenant environ 1 mg/litre de ces deux esters, marqués au ^{14}C (carbonyl), ont été incubés dans des conditions aérobies et anaérobies durant 1, 5, 7, 14 et 30 jours. La vitesse et les conditions de dégradation des deux esters accusent des différences marquées. Dans des conditions aérobies, 53% du DBP marqué est dégradé en dedans de 24 h et 98% en dedans de 5 jours; par contre, DEHP n'est dégradé que de 50% au bout de 14 jours. Dans des conditions anaérobies, la dégradation des deux esters est retardée. Dans un hydrosol enduit d'azote, la dégradation du DBP

[1]Trade names referred to in this paper do not imply endorsement of commercial products.

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