Rochester Committee
for Scientific Information
Rochester, NY

RCSI Bulletin 66
Phosphate in Washing Products

By: Olga Berg & George Berg
February 1970

THE ROCHESTER COMMITTEE FOR SCIENTIFIC INFORMATION
P. O. Box 5236, River Campus Station
Rochester, New York 14627

Water Pollution #6 February, 1970

Phosphate in Washing Products

by
Olga Berg and George Berg

Summary

Laundry detergents and presoaks tested for the R.C.S.I. contain a considerable amount of chained (poly-) phosphate. Other washday products and dishwashing detergents have less phosphate. The brand names are given with the amounts found. Since phosphates from laundering pollute fresh water lakes, some possible alternatives are suggested. It is also concluded that in many regions phosphates may be the most desirable water softeners since they are safe for both humans and other organisms.

Background

The R.C.S.I. was asked if there are low-phosphate laundering agents on the market. The questioner owns a home on a small, clear mountain lake, and he is eager to prevent the growth of excess algae in "his" lake. Many such lakes receive the outflow of laundromats and home washing machines and have responded to the added fertilizer with increased plant growth, weeds and algae.

Samples of 22 cleaning compounds were supplied by the members of Mr. Collins 6th grade class in the Brighton School System. A set of directions was prepared and tested by George and Olga Berg of the R.C.S.I. The class then performed the analyses under the direction of Olga Berg in the Spring of 1969.

The test material was weighed, dissolved in water, acidified and boiled to break the phosphate chains and produce phosphoric acid. After the acid was neutralized, addition of ammonium molybdate and stannous chloride caused the formation of molybdenum blue. The intensity of the blue color was measured in a Bausch and Lomb Spectronic 20 colorimeter at a wavelength of 650mu. The amount of phosphate was then calculated from the measurement. This technique was taken from "Standard Methods of the American Public Health Association" (1), the manual used by public health and water resource agencies. Step-by-step instructions used by the class are available from the Secretary of the R.C.S.I. Representative samples of soaps, detergents, detergents with enzymes (intended for both cold and hot water), presoaks, and fabric softeners were selected. Duplicate samples of Tide and All were analyzed, single samples of the others.

Results

The results of the tests are summarized in Table 1. It should be noted that the materials vary in density; a cupful (8 oz. or 432 cubic centimeters) may weigh from 70 to 240 grams (roughly 2 to 8 ounces). In addition, the amount recommended per machine load varies among the products. The presoak Axion had the highest amount of phosphate - 70 grams per cup, however, only ½ cup is recommended, making the amount in each machine load 35 grams. Punch contained 39 grams in each machine load, Cheer

TOTAL PHOSPHATE IN WASHING PRODUCTS

Analyses in Rochester and Milwaukee (NY Times)[1]

Washing Product	grams of phosphate in a cup of product	grams of phosphate in a machine load	weight of one cup of detergent	percent of weight as phosphate RCSI data	NY Times data
Water conditioner					
calgon	36	18	144	25%	
Presoak					
axion[2]	70	35	123	57%	43.7%
biz					40.4%
diaper pure					5.0%
Detergents					
ajax					28.2%
all - regular	26	33	146	18%	
bold[2]	12	15	75	16%	30.2%
bonus					22.3%
BREEZE					22.2%
cheer	27	34	80	34%	22.0%
cold power[2]	9	11	86	11%	19.9%
cold water all					9.8%
dreft					24.5%
drive[2]	18	23	83	22%	25.3%
duz					23.1%
fab					21.6%
gain[2]	17	21	74	23%	24.4%
ivory liquid	2		168	1%	
low suds	24	24	144	17%	
oxydol					30.7%
punch[2]	31	39	101	31%	25.8%
rinso	12	15	70	17%	
salvo cubes	15	10	157	10%	
salvo					35.5%
spic and span	22	11	217	10%	
surf	8	10	117	7%	
tide XK[2]	27	34	79	30%	30.6%
trend					1.4%
wisk	26	13	240	11%	7.6%
Soaps					
ivory flakes	3	5	43	7%	
ivory snow	0	0	58	--	
Culligans[3]	15	3.7	137	11%	
Instant Fels	5	7.5	79	6%	
Fabric Softener					
downy	0	0	259	--	

[1] analyses done by Limnetics Inc. of Milwaukee, printed in NY Times, December 14, 1969

[2] contains an enzyme (information only for those tested in Rochester)

[3] sold by Lan-o-sheen Inc.

and Tide XK a trifle less than Axion. Cold Power was determined to contain only 11 grams per load, but the New York Times, December 14, 1969 (2) reported it almost twice that high. Both these tests and those of the Times did indicate significant differences in amounts of phosphate among the popular heavy duty detergents.

Few soaps can be found on the market. We tested Ivory Snow, Instant Fels, and Culligan's (which is marked for use with a water softening system). Ivory Snow was phosphate free, therefore it would be the logical choice for use near small lakes, but it is not "heavy duty", and even lengthy soaking with it will not produce the results achieved by detergents. Instant Fels has 5 grams per load and is advertised for very dirty clothes. Its effectiveness is undergoing testing under R.C.S.I. direction. Culligan's soap contains 3.7 grams per load, however it is recommended only for soft water and is not generally available. Ivory Liquid (for dishes) was low in phosphate content, and the Times found Trend similarly low. Dishwasher detergents were not tested.

Discussion

1. Detergents and suds. If wash is to be clean the water and laundering material must be able to remove many kinds of soil. The detergents which have been used in recent years have been enormously successful as cleaning agents. The word detergent is used in two ways. It sometimes refers to just one of the active ingredients in the washday product (the detergent as distinguished from water softener, stabilizer, brightener, bleach, enzyme, etc.), and it sometimes refers to the whole mixture. This report uses the word both ways, but this paragraph refers to the chemical. Detergents can be classified according to whether microbes can break them into simpler units - i.e. whether they are biodegradable. Their chemical structure determines whether they can be called hard (hardly biodegradable) or soft (75-90% biodegradable under excellent conditions). Until recent years most detergents were hard, they persisted in streams and lakes, directly damaged fish by a coating action on delicate parts, and were sometimes visible as suds. Now all detergents are soft. Unfortunately, even the soft detergents are polluters because they are only 90% degradable and time must pass before they are fragmented and removed. "Super-soft" detergents (rapidly 100% degradable) are being sought by manufacturers, and alternate solutions are being examined (3).

2. Phosphate as fertilizer. Water is classified as soft or hard according to its mineral content and particularly to its calcium content. According to the Monroe County Water Authority, water in this area is moderately hard. Any detergent is more effective in soft water. Since polyphosphates are the best water softeners known it is a common practice to add them to detergents. These chained phosphates are a logical choice because they are biodegradable, they are changed to simple phosphates by bacteria and algae and added to the small amounts of phosphate naturally present in nearby lakes and streams. However, in many lakes the natural scarcity of phosphate is a critical factor that limits plant growth. Thus, the added phosphate is a potent fertilizer and it may produce "blooms" of algae which make the water murky and affect its taste and odor. In addition, increased growth of attached algae and weeds (aquatic flowering plants) choke shallow water areas and fill the lake with debris.

These facts suggest that the public could ask manufacturers to market laundering materials in two forms - one with a greater and the other with a smaller amount of phosphate, then the consumer could match the product to the situation. At very least, the container should state how much phosphate it contains. A phosphate-free, biodegradable softener would be most desirable, but, in its absence, it should still be possible to use the minimum amount of polyphosphate required to obtain a clean wash.

Although our results and those published in the Times are in general agreement, there are differences which may be compared in Table 1. Possible explanations include: (1) Different technique in analysis, (2) Incomplete breakdown of phosphate chains by boiling for the standard length of time, (3) Differences in the actual phosphate content of the product from one batch to another or in different regions of the country or at different times.

3. Wash water compared with sewage. The R.C.S.I. has also been asked to compare the amount of phosphate released in a week's washing with the amount of phosphate excreted in a week by an average family, using all available washing aids.

	each machine load	week's wash (5 loads)
presoak	35	175
detergent (from box)	34	170
calgon	18	90
fabric conditioner	0	0
	87 grams	435 grams

The same family also eats and excretes a certain amount of phosphorus each day. The following figures are from the Recommended Dietary Allowances, published by the National Academy of Sciences (5). We used maximum figures for adults, teen-agers and children, and assumed that all the phosphorus not specifically held in the body (e.g. as bone) is excreted.

	phosphorus ingested each day	phosphorus excreted each day
child	.800	.650
child	.800	.650
teen-ager	1.400	1.000
adult	.800	.800
adult	.800	.800
	4.600 grams	3.900 grams

This family excretes 3.9 grams of phosphorus each day, or 27.3 grams each week. Converted to phosphate for comparison it is equal to 82 grams each week. Thus, even under the best conditions a family puts 82 grams of phosphate into the water each week, and it may put in as much as 517 grams.

It is not necessary to use every washing aid to clean clothes.

(a) Presoak: According to tests performed by Consumers' Union (4) soaking with a detergent for a few hours before starting the washing cycle is just as effective as using a presoaking agent, emptying the machine, refilling it and then washing with a detergent. The Consumers' Union procedure cuts both the cost of the wash and the amount of phosphate added to the water.

(b) Wash day product: Punch will add 195 grams of phosphate to the water each week, Instant Fels only 38. Each housewife can try the various brands and find the one with the least phosphate that gets her clothes clean enough for her needs. If you live in the drainage basin of a small fresh water lake, it may be necessary to sacrifice some whiteness for low phosphate content.

(c) Calgon: Probably not necessary. If your detergent softens the water then the water is soft. Another water softener will only double the amount of phosphate - probably beyond the point where it is useful.

(d) Fabric conditioner: One bright spot - Downy, a fabric softener does not contain phosphate.

So, a careful housewife can cut the phosphate released from washing from 435 to 38-195 grams per week.

4. Control of the Problem. There are other water softeners besides polyphosphates. Ethylene diamine tetraacetate (EDTA) is one. The R.C.S.I. has been trying to find out if it is biodegradable and we have two indications that it is. (1) Dr. Marquis, at the University of Rochester Medical School, tested it for us. This is a quote from his report: "It is possible to cultivate a number of common bacteria on media containing EDTA as sole nitrogen source. The capacity of a bacterium to grow on media of this type is presumptive evidence that it can degrade EDTA. The simplest medium we used contained 0.1% KH_2PO_4, 1% glucose, 1% $CaCO_3$ and 0.1% EDTA. The percentages are weight per volume figures, and distilled water was used to dissolve the ingredients. The bacteria that were able to grow on this medium were Serratia marcescens, Bacillus megaterium and Escherichia coli. These organisms can often be isolated from soil and water." (2) Industrial Biochemicals, the firm that makes the chemical, informed us that to the best of their knowledge EDTA is biodegradable. They also say that it is competitive in price with polyphosphates and is currently being used to some extent as a water softener. Obviously, this may be a solution to the phosphate problem, and further research is needed on its use with detergents and its effect on the environment.*

If your drain leads into a lake, the lake will become weed-grown. This was explained in R.C.S.I. Bulletins (6,7) and an FWPCA report (8). Neither septic tanks nor ordinary (primary or secondary) sewage treatment plants remove the phosphate. Tertiary treatment with special phosphate removal is necessary. Such treatment is available both for large sewage treatment plants and for small (package) plants (R.C.S.I. bulletins). Phosphate will be removed at the regional plants under construction in Monroe County, and the plant planned for Conesus Lake in Livingston County.

*Dr. Bruce Ristow has offered a strong warning against careless adoption of EDTA as a water softener. It does contain nitrogen, which is another principal element among fertilizers, although nitrogen appears relatively less critical than phosphorus as this time. The principal danger is that EDTA has an enormous capacity for forming combinations with calcium and magnesium compounds many of which are highly critical in the natural community. His observation underscores the need for an ecological attitude when assessing the "value" of any product released by man into the environment.

Even a septic tank might be supplied with such tertiary treatment. Phosphate compounds are precipitated by calcium, and it is possible in theory to hold back all the phosphate if the outflow of a septic tank trickles through a bed of lime on the way to the lake. We know of no tested, practical method to build such a lime bed, and we invite comments of chemists and engineers among our readers.

For individuals and groups concerned with pollution by laundry products, the R.C.S.I. suggests these actions:

(1) Launder with a soap or a washday product low in phosphate and eliminate extra presoaks and chemical water softeners.

(2) Write requests that ask that detergent manufacturers market their products low in phosphate and label the percentage on the container. This may stimulate them to look for other non-fertilizing water softeners.

(3) The community can be asked to give priority to building tertiary sewage treatment plants, which remove phosphate.

Literature Cited

1. Standard Methods for the Examination of Water and Wastewater Including Bottom Sediments and Sludges. Twelfth Edition. Published jointly by American Public Health Association, American Water Works Association, Water Pollution Control Federation. 1790 Broadway, New York N.Y. 10019

2. Phosphates in Detergents. The New York Times. December 14, 1969.

3. Wayman, Cooper, H., A Hard Look at Soft Detergents. Bulletin of the Atomic Scientists. April 1965, pages 22-26.

4. Do Enzymes Help in Laundry? Consumer's Reports. January 1969, page 44.

5. Recommended Dietary Allowances. Seventh Edition 1968. A report of the Food and Nutrition Board. National Research Company Publication 1964. National Academy of Sciences, Washington D.C.

6. Christensen, J. Roger, Neal Dunkleberg, Herman Forest and David J. Wilson, Sewage Phosphates and Algae in Lake Ontario. Bulletin of the Rochester Committee for Scientific Information, June 1967.

7. Wilson, David J., Sewage Phosphates and Algae in Lake Ontario. II. Report of the Lake Erie Enforcement Conference Technical Committee. Bulletin of the Rochester Committee for Scientific Information, June 1967.

8. Chemical Removal of Phosphorus Feasible. Chemical and Engineering News. February 1968, pages 42-43.