A SUMMARY OF POLLUTED IRRIGATION WATER STUDIES*

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A polluted irrigation water conference was held January 27, 1950, at El Paso, Texas. This conference was held under the joint auspices of the Environmental Health Study Section, Division of Research Grants and Fellowships, National Institutes of Health, Public Health Service, Federal Security Agency, the El Paso City-County Health Unit, and the Texas State Health Department.

A total of 73 persons registered for this conference. Included were sanitary engineers, bacteriologists, biologists, reclamation engineers, agricultural engineers, superintendents of water and sewage plants, hydraulic engineers, chemists, health officers, parasitologists and veterinarians.

The principal states represented were: Arizona, California, Colorado, Texas and Utah. Federal agencies were: National Institutes of Health, the Virus and Richettsial Laboratory, Tropical Disease Laboratory, Division of Water Pollution Control, all of the Public Health Service. Others were: the Pan American Sanitary Bureau, United States Bureau of Reclamation, United States Geological Survey, Southwest Research Institute and the Department of Agriculture. The University of California, Texas Western College, New Mexico A. & M. and Michigan State College were also represented.

The program included the following papers and discussions:

1. The Polluted Irrigation Water Picture in: (a) Arizona; (b) California; (c) Colorado; (d) Texas; (e) Utah.
2. Epidemiological Aspects of Polluted Irrigation Waters.
3. Research in Progress on Polluted Irrigation Water.
   (a) Studies of the incidence of pathogens in polluted irrigation water.
   (b) Studies of the incidence of pathogens and indicator organisms in vegetable washings.
   (c) Behavior of pathogens and indicator organisms in soils.
   (d) Studies on vegetables irrigated with sewage polluted waters.
4. Machines for Vegetable Washing.
5. Utilization of Waste Water for Replenishing of Underground Reservoirs.
6. Sewage Sludges for the Use of Soil Improvement.
7. Present Standards for Irrigation Waters in Various States and Their Limitations.
8. General Discussion of all the papers.

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Now the Problem:

Approximately 60% of the total land area of the United States lies west of Texas, Oklahoma and Kansas. In other words, the 17 western states. Approximately 30% of all crops grown in these states come from irrigated land. Fifty percent of all vegetables and 60% of all fruits produced come from irrigated lands of the west. This produce finds its way to the markets in practically every state in the union.

For sometime health authorities have been expressing some concern in relation to such produce irrigated with polluted water and the potential health hazards that might be involved.

The community wastes,—domestic, industrial and agricultural,—are usually ultimately disposed of through streams and other water courses. However, in the west most of these wastes, too frequently untreated or only partially treated, eventually are disposed of on some farmer's ranch as irrigation water.

The sanitary engineers, particularly those in public health agencies, are frequently required to make decisions regarding the degree of sewage treatment necessary to adequately protect the public health and welfare. Such decisions are usually based upon highly controversial criteria. Realistic standards upon which to base such decisions are quite noticeable by their absence.

In the absence of standards based upon scientific studies, health authorities have, perhaps, taken a somewhat severe stand in some instances regarding the use of sewage plant effluents and polluted irrigation waters. The very nature of the transmission of communicable diseases, particularly the intestinal group, would dictate such policies in the absence of a thorough understanding. However, on the other hand, there are those in the design and operational field who want to do too much, leaning in the other direction. The whole question of reclaimed water from sewage apparently is still in the trial period.

The 1942 Proceedings of the American Society of Civil Engineers state:

"Standards for the use of sewage and its by-products promulgated by health authorities afford the best criteria in this field and generally emphasize that:

(a) Raw sewage or its untreated solids content, or the soil which it has recently irrigated, shall not come in contact with food stuffs designated for food consumption, nor shall livestock graze upon pastures irrigated therewith.

(b) Forage crops which are to be harvested and cured may be irrigated with untreated effluent from adequate subsidence tanks.

(c) For use in the cultivation of human foodstuffs, particularly those to be eaten raw, the water reclaimed from sewage must be well oxidized and *thoroughly sterilized* at all times."

Just how *thorough sterilization* is to be realized I do not understand. Certainly this is a very impractical statement.

There are nine of the western states that have laws or regulations regarding the use of sewage, sewage effluents, and/or polluted water for irrigation. These states issue permits to irrigators using effluents. Three of these states have set up definite criteria upon which permits can be issued. However, it is interesting to note that these have been found so impractical and unrealistic that the usual irrigation water, not polluted with sewage effluents, cannot meet them. Arizona is one of the nine states requiring a permit but does not have definite standards. Each problem is judged on its merits. The general policy is not to permit sewage plant effluents, regardless of treatment, to be used for irrigating vegetable crops. However, there is no control over irrigation waters that may be polluted by individual septic tanks, sewer lines or privies. This condition does exist for we have found them from time to time. To attempt to inspect all the irrigation canals routinely that serve more than a million acres of land in Arizona would be quite an undertaking.

The Public Health Service has a study of the quality of irrigation waters under way along the South Platte River basin in Colorado. Perhaps this study will contribute to possible recommended guides which might be applicable to the quality of irrigation waters. Certainly some information will be obtained to add to the little we now have.

Studies on vegetables irrigated with sewage polluted waters were started July, 1949, in the Denver, Colorado area by the Public Health Service. However, the preliminary work in this research has been essentially to determine the pollutional load of the irrigation water, of the soil and of the vegetables in terms of coliform and enterococcus (strep. fecalis) densities.

There were two attempts to find enteric pathogens: one, on irrigation water, soil and celery samples, failed; the second, on raw sewage, resulted in the isolation of Salmonella, Group B (Kauffman—white).

No conclusions could be reached at this time. However, the results, so far, are summarized as follows:

1. The water used for irrigating vegetable crops shows relatively high coliform and enterococcus (strep. fecalis) densities.
2. The coliform density of the soil appears to be of the same order of magnitude as that of the water with which the soil is irrigated.
3. The enterococcus density of the soil appears to have no relation to that of the waters with which the soil is irrigated.
4. Leafy vegetables, such as lettuce, cabbage and celery, show coliform densities that equal or exceed those of the irrigation water.
5. Strawberries and smooth vegetables (tomato, pepper) show very low coliform densities, regardless of the densities in the water and in the soil. However, carrots show high coliform densities.
6. Enterococci were recovered from all of the 12 irrigation water samples

examined; from 5 of 11 soil samples; from 2 out of 13 leafy vegetable rinses; from none of the strawberry, tomato, pepper and carrot samples; from only 1 out of 8 blended vegetables. In all, out of 51 samples examined, enterococci were recovered from 20 samples.

7. One blended sample (lettuce) yielded enterococci, although its rinse failed to show it.

8. Salmonella, Group B, was isolated from raw sewage.

It is hoped that this research will continue.

Doctor W. L. Mallman, Michigan State College, has been conducting a study on the survival of enteric bacteria in sewage contaminated soils.

One of the principal objectives of the studies being made on the sewage contaminated irrigation waters has been a search for organisms that could be used as reliable indicators of public health hazards.

The coliform group of bacteria have been quite useful in measuring the purity of water supplies, particularly community supplies. They have also been useful in measuring the public health hazards of streams receiving sewage.

However, there is considerable doubt as to their value for measuring the sewage contamination of irrigation waters, irrigated soils and the vegetables grown on sewage polluted soils.

The studies of Doctor Mallman were limited to the behavior of enterics in soils of various types. Truck gardening soils vary considerably so representative types were selected from sand, clay, loam and muck.

The soil cylinders of the various soil types were treated with raw sewage, sewage effluents and raw treated sludges.

Examinations were made for coliforms, streptococci fecalis or enterococci and total count. Repeated sampling over the entire growing season showed that the total counts for each soil remained practically constant, coliform indices fell very slowly, and enterococci (strep. fecalis) died out gradually. Where soils received sewage-laden waters each week, the enterococci stayed at a high level comparable to the coliform. Both coliform and enterococci remained at high levels in rich soils or soils receiving large amounts of sewage solids, either digested or raw sludge.

Four sewage treated soils are reported, namely, Ostemo sand, Brookston clay, Isabella loam and muck. Coliforms disappeared more rapidly in the sand and stayed at a high level in the loams and muck. Enterococci or streptococci fecalis died out in from 35 to 63 days. Total counts remained constant throughout the period of the test (84 days).

To determine the relationship of the indicator organisms (coliforms and streptococci) to enteric pathogens, strains of S. typhosus of known pathogenicity, strains of coliforms and strains of fecal streptococci were added to the various soils. Samplings were made each week until the typhoid bacilli and the streptococci disappeared.

Typhoid bacilli survived in:

Muck	40 days
Brookston clay	23 days
Ostemo sand	17 days
Miami loam	7–17 days

The typhoid bacilli remained pathogenic throughout their sojourn in the soil. Coliform organisms showed only a slight diminution throughout the period of test. The streptococci reductions in numbers paralleled the reductions for the typhoid bacilli. This data indicates that streptococci are a better indicator of sewage pollution than are the coliform group of organisms.

A new test procedure for fecal streptococci has been developed. Professor S. G. Dunlop, bacteriology department, University of Colorado School of Medicine, reported on "Studies of the Incidence of Pathogens in Polluted Irrigation Water."

Preliminary studies on the incidence of protozoa and helminths indicate that cysts of Endamoeba histolytica, Endamoeba coli, Endamoeba nana and Iodamoeba büetschlii may be present in raw sewage, but these forms have generally not been recovered from the treated effluent or from irrigation water, except perhaps in one instance. Ascaris ova and hookworm-like larvae have appeared in raw sewage, sewage effluent, and some irrigation water. Efforts are now being made to culture the amoeba to more definitely determine the species encountered; and larger samples than one liter are planned for the studies on effluent and irrigation water.

A study of the incidence of indicator organisms in vegetable and soil washings under natural conditions of irrigation is under way at Texas Western College. The study has been too short at this time to arrive at any conclusions. In addition, modifications of technics have had to be developed. With these new technics excellent results are now materializing, and it is hoped that this summer's work will yield satisfactory results on which to make conclusions.

The Public Health Service, Environmental Health Center at Cincinnati, is engaged in bacteriological research on irrigated fruits and vegetables. They plan to initiate epidemiological investigations during the current year.

The problem confronting public health authorities is the development of irrigation water quality standards which will adequately reflect the health importance of irrigation water use and at the same time be realistic and practicable in application.

Reviewing the literature reveals evidence which tends to support the suspicion that irrigation of certain crops with polluted water constitutes a serious public health hazard. However, the basic epidemiological data

needed to confirm this suspicion are not available. This is a serious deficiency and will have to be eliminated before the true public health significance of irrigation water practice can be determined and equitable irrigation water standards developed.

Doctor W. L. Mallman made another report, this one on "Machine Washing of Vegetables."

For a number of recent years, machine washing of vegetables has been adopted in all parts of this country. This has resulted in a cleaner product at a lower cost of washing. This method also provides an opportunity to use ice water to reduce the temperature of the product rapidly so that the storage life of the product will be extended materially. In addition to the washing and cooling process, a sanitizer can be added to the water to destroy microorganisms present on the fruits and vegetables.

The use of mechanical washing equipment with chilling and sanitizing facilities for fruits and vegetables should be encouraged by health authorities as a means of lessening health hazards, as well as an economic measure to assure the public of cleaner, fresher and more nutritive food products.

The final conclusions reached by the conference are summarized as follows:

1. Many phases of the problem were discussed by the speakers.

2. From the limited available epidemiological information, it appears that no major public health hazards have developed from present irrigation practices, due largely to the vigilance and good practical supervision provided by health departments.

3. More research and studies are needed to develop methods which will permit further utilization of existing and potential irrigation waters. It is agreed that there is need for better indices of suitability of water for irrigation purposes, and that further investigation of this subject is essential.

4. The United States Public Health Service should continue and expand its activity in stimulating and carrying out research in the entire field of irrigation water uses as related to public health.

5. Industry should be further encouraged in the development and use of vegetable washing and sanitizing equipment.

6. It is recommended that the economics of using sewage effluents as irrigation waters be included in the studies of the overall problem.

ESTUDIOS SOBRE AGUAS DE IRRIGACIÓN CONTAMINADAS (*Sumario*)

En enero 27 de 1950 se celebró una conferencia en el Paso, Texas, con el objeto de discutir la contaminación de aguas de irrigación, y a la que asistió un grupo de 73 personas integrado por ingenieros sanitarios, agricultores,

bacteriólogos, biólogos, superintendentes de plantas hidráulicas y de drenaje, químicos, funcionarios sanitarios, parasitólogos, veterinarios, y otras personas interesadas, de los Estados de Arizona, California, Colorado, Texas y Utah.

Los trabajos presentados versaron sobre los diversos aspectos del peligro que las prácticas de irrigación con aguas contaminadas tienen para la Salubridad, siendo éste un problema que desde años preocupa a los funcionarios sanitarios.

Los 17 Estados occidentales, que comprenden aproximadamente el 60% de la superficie de Estados Unidos, dependen de la irrigación para el cultivo de sus tierras; y el 50% de todos los vegetales y el 60% de todas las frutas que se venden en los mercados del país, provienen de esas tierras de regadío en esos Estados.

Las aguas negras domésticas, industriales y agrícolas que por lo general, desembocan en arroyos o corrientes naturales, en otras partes del país, se encaminan frecuentemente, parcialmente tratados o sin tratamiento alguno a las grandes acequias de irrigación en los Estados occidentales.

A los ingenieros sanitarios, especialmente aquellos en el servicio de salubridad toca frecuentemente decidir sobre el grado de tratamiento necesario que se debe dar a esas aguas servidas a fin de proteger adecuadamente la salud del público en general, pero esas decisiones se basan por lo general en un criterio arbitrario.

En las actas para 1942 de la Sociedad Americana de Ingenieros Civiles aparecen ciertas estipulaciones que rigen las normas a seguir con relación al uso de aguas servidas o sus residuos para la irrigación de los cultivos, y la mayoría de los Estados occidentales o sea nueve de éstos, han decretado leyes que rigen el uso de estas aguas servidas para irrigación, pero la regla general es la de permitir el uso de aguas negras, prescindiendo del tratamiento que se les dé, para la irrigación de vegetales.

El Servicio de Sanidad y las Universidades de Texas, Michigan, Colorado y otras están llevando a cabo estudios de investigación sobre los diferentes aspectos del peligro que dichas aguas de irrigación representan para la Salubridad y el bienestar público en general.

De los datos epidemiológicos así obtenidos como de las deliberaciones llevadas a efecto en el curso de la Conferencia, se llegó a las siguientes conclusiones: que debido a la vigilancia de los departamentos de Salubridad, el peligro a la sanidad por consecuencia de las prácticas actuales de irrigación, no había aumentado; que a fin de obtener mejores índices de la pureza de aguas de riego, es menester intensificar los estudios de investigación que permitan establecer métodos para la mayor utilización de los abastecimientos existentes y potenciales; que el Servicio de Salubridad de los Estados Unidos debería estimular e intensificar dichos estudios con relación a la utilización de las aguas de irrigación en todos sus aspectos; que se debería fomentar el que las plantas industriales utilicen el equipo de lavado para vegetales; terminando con la recomendación de que la economía de utilizar efluentes de aguas negras para irrigación fuera incluída en los estudios del problema general.