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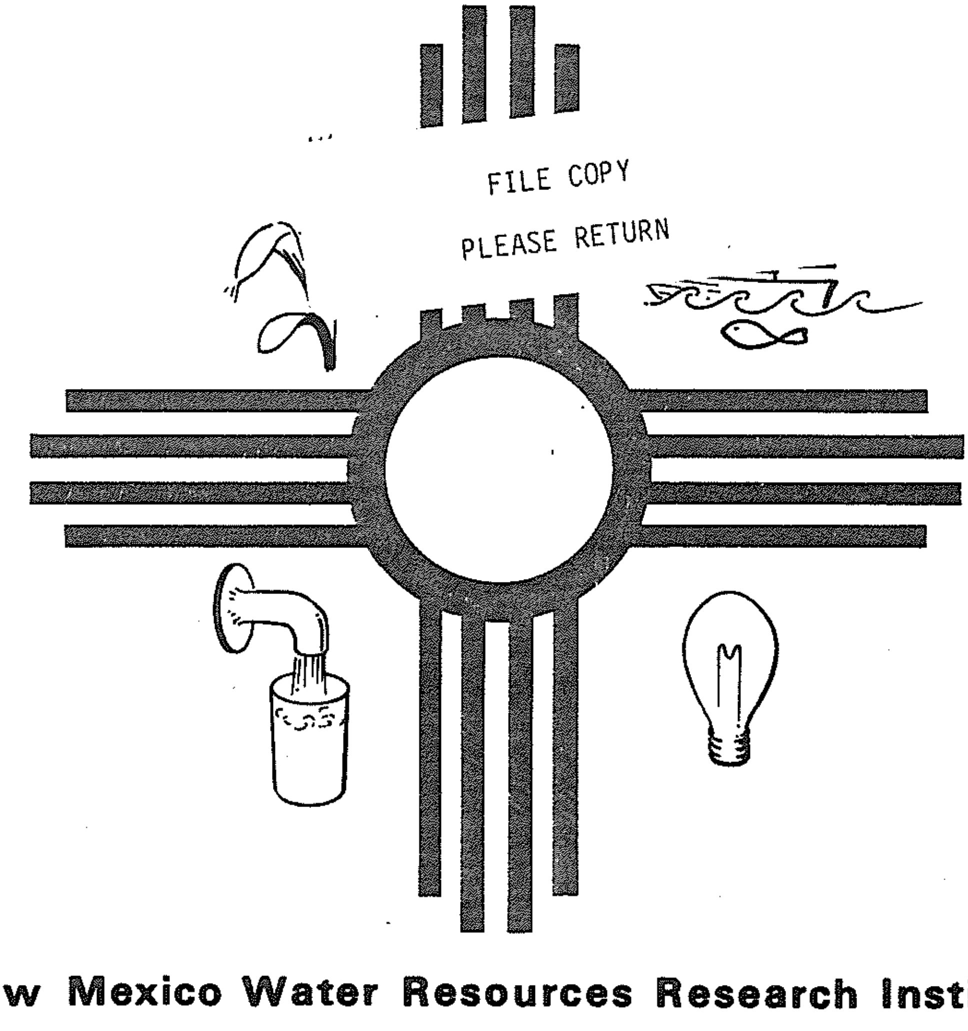
Technical Completion Report
Project No. A-054-NMEX



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Feedlot Runoff and Sewage Effluent as Potential Water Pollutants with Emphasis on Nitrogen and Phosphate Levels and Oxygen Depletion

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TECHNICAL COMPLETION REPORT
PROJECT NO. A-054-NMEX

New Mexico Water Resources Research Institute
in cooperation with
New Mexico Institute of Mining and Technology
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ABSTRACT

The effects of the input from a small sewage plant and a feedlot on a small drainage ditch were investigated. Primary parameters used in the study were bacterial numbers and type, chemical forms of nitrogen, phosphate and dissolved oxygen. Originally, it was planned to use chemical assays and bacterial typing to identify the source of various pollutants. Success was partial. It was found that the feedlot contributed both Kjeldahl nitrogen and nitrate to the drain. No phosphate contribution was detected. Oxygen levels were unaffected by the feedlot except after storm runoff. The feedlot runoff after heavy rainfall was very high in nitrate, Kjeldahl nitrogen, phosphate and BOD. During the dry time of the year, significant amounts of ammonia were released. Microbial studies were difficult to assess due to high levels associated with agricultural drains. These drains also interfered with chemical studies because of high background levels of pollutants.

Research Project Objectives:

1. To measure the effects of a sewage plant and a feedlot on dissolved oxygen levels and BOD values of a small drainage ditch.
2. To determine the nitrogen contribution of the above and what chemical forms of nitrogen are present.
3. To assay the effect of the drainage ditch on the water quality of the main diversion canal.
4. To evaluate the storm runoff water from the feedlot as to porbable harmful effects.
5. To carry out a characterization of microorganisms present and to use this as a means of identifying input source.

Research Project Findings:

1. That the feedlot contributes Kjeldahl nitrogen and nitrate to the drain. No phosphate elevation was detected.
2. That the magnitude of this contribution is about 10% above baseline.
3. On the average no effect on dissolved oxygen was noted.
4. That storm runoff water could cause a potential problem unless contained.
5. Much nitrogen from the feedlot is lost as ammonia.
6. That input from agriculture and other sources so contaminate the drain that quantitative assignment of pollutant input was difficult.
7. Except at low water in the main diversion canal, effects of the drain were minimal.

The research project reported here concerned the probable contamination of surface water by a small municipal sewage plant and by a cattle feedlot. The potential for introduction of pollutants was felt to be high and worthy of study. Special emphasis was put on potential effects on oxygen levels, nitrogen species and phosphate.

The area studied is located in a rather arid environment. The rainfall during the research period was about eight inches per year. Most of this fell in the months of July and August. Temperatures in summer may reach over 37° and down to 0° in the winter. The prevailing winds are from the southwest and often very dry. Much of the year is marked by warm days and cool nights.

The city of Socorro has little industry that contributes to the water load. Socorro is mostly a retailing center. The biggest business in town is the New Mexico Institute of Mining and Technology, which had somewhat over 1,000 students and staff. Farming and ranching are important occupations in the area with extensive acreages of irrigated land. At present the major crop is alfalfa with corn milo, etc. also being important. Some small grains are also grown as well as vegetable crops. Cotton is rarely grown in the area which represents a major change from ten years ago. Livestock production is also of importance, with cattle in the greatest number. These are raised under a range of conditions. Some are turned loose to tend for themselves along the river, others are pastured, and large numbers are confined in feedlots.

In some parts of the area chemical fertilizers are heavily used. The most popular are liquid ammonia, ammonium phosphate, and super phosphate. Many farmers use no fertilizer at all and a few use only livestock manure.

The irrigation water itself including that which enters the Luis Lopez drain tends to be high in sediment or settleable solids. This is especially true when the Rio Puerco and Rio Salado are running. Most of the area farmers try to avoid irrigating when the water from the Rio Puerco is going through, but cannot always do so. This high sediment introduced special problems in our sampling and assays. Again, contribution from the Puerco created the most severe problems.

Experimental:

This research was conducted on the Luis Lopez drain located just east of Socorro, New Mexico. The water in the early part of the drain is derived mostly from ground water seepage. As the drain progresses south it receives the effluent from the Socorro sewage treatment facility. This plant treats slightly over one million gallons of influent per day. Station C was located above the sewage discharge and Station D below the discharge. Stations E and F were further along the ditch and situated so as to each be below a small ditch that carried water during the irrigation season. Station F, was located just above a beef cattle feedlot and Station G just below. Station H was also below, located after the intersection of a small return flow ditch with the main drain. A station was established on this ditch and designated Q. During the irrigation season Q receives some irrigation water. From December through March the water here is ground water seepage. Station I was located well below H in a position to receive influent from irrigated fields. Location J was the site where the Luis Lopez drain enters the main diversion canal. Stations K and L were on the diversion canal above and below J respectively. The total length of ditch usually monitored was about 5.5 miles. However, temporary stations were established as checks from time to time.

During periods of heavy rainfall, samples were collected from the runoff, a small pond where runoff accumulated and at the sampling sites. These times were unpredictible as might be expected.

Samples at these stations were collected just below the water surface and also slightly above the bottom. Samples to be used for nitrogen analysis were acidified with sulfuric acid and saturated with chloroform in order to trap ammonia and inhibit microbial transformations of the chemical forms of nitrogen. Assays were carried out as soon as possible after sampling, most analyses being completed within 36 hours.

The pH was determined in the field using an Orion model 407 meter. This meter was also used to assay fluoride and sodium in the field using Orion specific ion electrodes and to measure redox potential employing a Corning 476060 platinum electrode. Dissolved oxygen levels were done on a Yellow Springs Instruments model 54 oxygen analyzer. The same instrument was used to measure biological oxygen demand (BOD). Conductivity and salinity were determined with a YSI model 33-SC-T water pollution meter.

Nitrite[1] analyses were carried out according to *Standard Methods for the Examination of Water and Wastewater* using the sulfanilic acid method. Nitrate, Kjeldahl nitrogen, ammonia, and other nitrogen species were measured by methods described by Golterman[2]. Biological oxygen demand[3] and phosphate[4] were determined by standard methods. Boron presented difficulties due to interference from high nitrate levels in some samples. The method chosen was the carminic acid method with pretreatment to remove nitrate. Urea levels were measured as described by Emmett[5]. Sulfide and sulfate when measured were assayed according to "*Standard methods*".

After the study had progressed for a time, it was felt that significant amounts of gaseous ammonia were being given off by the feedlot. To test for this, several small sampling rigs were constructed which somewhat resembled chicken waterers. They consisted of a roof, a screened chamber and a container 6 x 6 inches. This corresponds to a surface area of about 225 cm^2 or 0.25 ft^2. The container was filled to a depth of 1 inch with 0.01 n sulfuric acid, saturated boric acid or water. These were usually assayed for ammonia every two weeks.

Results:

The following tables are average values for the data collecting period. The data has been assembled according to the irrigation season and the time of the year when this water is not entering the system under study. These do not show peaks such as occur during heavy runoff. These will be discussed later. The data in the tables are averages of several assays.

Kjeldahl Nitrogen (as ppm NH$_3$)

Period	C	D	E	F	F$_1$	G	H	I	J	K	L	Q
June-74 - Nov -74	1.90	20.0	17.0	16	-	20	15	-	9.2	1.6	3.05	-
Dec -74 - Mar -75	4.90	20.0	20.0	-	20.0	23	5.8	-	3.7	5.3	5.0	2.85
Mar -75 - Nov -75	6.40	10.65	7.40	5.23	5.94	6.92	5.0	6.15	2.26	3.76	4.18	6.50
Dec -75 - Mar -76	4.76	12.00	10.86	6.96	5.61	6.24	2.38	3.25	2.62	2.57	3.16	2.01
Apr -76 - Nov -76	1.87	12.17	5.01	4.46	5.99	4.22	1.63	1.09	1.00	0.90	1.37	1.64
Dec -76 - Mar -77	3.12	14.74	13.0	5.66	7.71	9.40	2.92	3.01	3.35	3.44	2.37	1.48
Apr -77 - July-77	3.70	6.01	6.15	3.70	2.25	3.00	1.59	2.19	1.42	0.94	2.50	1.54

Dissolved Phosphate (mg/ℓ)

Period	C	D	E	F	F_1	G	H	I	J	K	L	Q
Jan -75 - Mar-75	6.43	6.27	6.69	6.11	5.90	5.83	5.52	5.37	5.59	6.25	6.09	4.36
Apr -75 - Nov-75	6.05	2.75	2.41	2.23	2.22	2.30	2.12	2.03	2.26	2.09	2.17	2.26
Dec -75 - Mar-76	1.45	1.15	2.06	1.15	1.15	1.45	2.36	-	2.52	4.18	3.88	3.42
Apr -76 - Nov-76	2.53	3.25	2.50	2.51	4.21	2.78	3.24	3.64	3.09	2.99	3.58	3.93
Dec -76 - Mar-77	0.17	9.50	8.18	4.97	4.94	5.96	1.24	1.18	1.77	1.70	1.81	0.12
Apr -77 - Jul-77	0.55	4.11	3.25	2.05	1.61	1.60	0.69	0.76	0.60	0.37	0.46	0.54

Dissolved Oxygen (mg/ℓ)

Period	C	D	E	F	F_1	G	H	I	J	K	L	Q
Nov -74 - Mar-75	8.6	4.9	5.4	5.4	6.3	6.4	8.3	8.9	9.2	9.1	9.1	9.4
Apr -75 - Nov-75	7.6	4.2	7.8	7.5	8.0	8.0	8.3	8.4	8.6	7.9	7.9	7.9
Dec -75 - Mar-76	8.6	7.7	8.1	8.4	8.7	8.3	9.5	9.2	9.0	8.4	8.7	8.3
Apr -76 - Nov-76	6.8	6.4	7.8	8.1	8.3	8.3	8.2	8.6	9.0	8.1	8.2	8.4
Dec -76 - Mar-77	10.0	8.6	7.9	8.9	8.4	9.2	9.5	9.6	9.5	9.6	9.6	9.4
Apr -77 - Jul-77	6.5	6.6	6.7	6.9	7.0	7.0	7.2	7.2	7.4	7.6	7.5	7.3

Nitrate-N (mg/ℓ as NH_3)

Period	C	D	E	F	F_1	G	H	I	J	K	L	Q
Dec -74 - Mar-75	15.7	12.3	11.98	12.12	12.15	10.85	15.51	15.44	14.55	6.82	7.16	11.1
Apr -75 - Nov-75	10.3	8.3	7.77	6.98	7.14	6.69	6.92	6.92	7.12	5.35	5.51	6.92
Dec -75 - Mar-76	6.41	8.22	7.03	7.77	6.98	7.02	7.18	7.37	7.68	4.88	5.81	7.95
Apr -76 - Nov-76	9.35	8.33	8.20	7.87	7.89	8.03	8.35	8.56	8.50	7.95	7.84	8.50
Dec -76 - Mar-77	6.65	19.94	14.03	6.65	7.38	8.86	4.43	11.03	8.86	10.33	10.74	2.95
Apr -77 - Jul-77	2.63	18.7	17.58	19.58	17.24	15.14	10.12	11.58	11.58	6.90	7.82	10.71

Nitrite (mg/ℓ)

Period	C	D	E	F	F_1	G	H	I	J	K	L	Q
Dec-74 - Mar-75	0.067	0.037	0.036	0.035	0.029	0.094	0.022	0.215	0.244	0.205	.264	.0037
Apr-75 - Nov-75	.023	.077	.089	.203	.214	.116	.160	.159	.016	.020	.017	.017
Dec-75 - Mar-76	.035	.143	.125	.115	.124	.158	.065	.086	.088	.112	.179	.061
Apr-76 - Nov-76	.021	.066	.062	.064	.085	.05	.055	.032	.061	.047	.040	.047
Dec-76 - Mar-77	.060	.857	.413	.212	.189	.200	.066	.126	.176	.137	.129	.018
Apr-77 - Jul-77	.015	.735	.351	.198	.246	.222	.075	.084	.070	.021	.024	.033

Ammonia (mg/ℓ)

Period	C	D	E	F	F_1	G	H	I	J	K	L	Q
Dec-74 - Mar-75	0.63	3.20	3.30	3.39	3.26	3.94	0.76	1.01	0.93	0.51	0.65	1.29
Apr-75 - Nov-75	0.21	0.27	0.26	0.24	0.21	0.21	0.21	0.24	0.22	0.24	0.33	0.26
Dec-75 - Mar-76	0.63	3.22	2.44	1.95	1.64	2.01	0.75	0.68	0.20	0.11	0.13	0.12
Apr-76 - Nov-76	0.72	4.89	3.59	1.93	2.20	1.77	0.53	0.48	0.49	0.52	0.75	0.60
Dec-76 - Mar-77	5.01	9.75	8.44	4.47	3.94	4.22	0.83	1.68	0.95	0.57	0.20	0.55
Apr-77 - Jul-77	1.80	3.78	2.32	2.02	1.22	0.79	0.49	0.78	0.56	0.59	0.56	0.56

pH

Period	C	D	E	F	F_1	G	H	I	J	K	L	Q
Mar-75 - Nov-75	7.87	7.77	7.99	7.99	8.02	8.00	8.07	8.09	8.22	8.10	8.10	-
Apr-76 - Nov-76	7.67	7.50	7.88	8.0	8.10	8.00	8.10	7.90	7.90	8.10	8.10	8.10
Dec-76 - Apr-77	7.70	7.80	7.90	8.0	8.1	8.1	8.3	8.2	8.3	8.2	8.3	8.2
Apr-77 - Jul-77	7.7	7.7	7.8	8.0	8.1	8.1	8.1	8.1	8.1	8.1	8.2	8.1

Temperature (°C)

Period	C	D	E	F	F_1	G	H	I	J	K	L	Q
Jun-75 - Nov-75	19	20	21.6	22	21.7	21.7	21.7	21.7	22.5	23	22.7	21.8
Dec-75 - Mar-76	9.1	10.6	10.7	10.7	10.2	9.5	11.4	10.5	10.6	5.4	5.9	10.8
Apr-76 - Nov-76	13.7	16.1	16.3	15.4	14.6	17.4	16.6	16.6	16.8	15.8	15.6	16.6
Dec-76 - Mar-77	9.5	10.9	10.8	10.2	10.2	9.9	10.3	9.9	10	7.4	7.4	16
Apr-77 - Jul-77	14.8	17.2	17.3	17.2	16.8	17.0	16.8	16.8	16.9	16.0	16.0	16.0

Boron (mg/ℓ)

Period	C	D	E	F	F_1	G	H	I	J	K	L	Q
Nov-74 - Mar-75	0.30	0.40	0.47	0.40	-	0.27	0.31	0.5	0.4	0.1	0.1	0.20
Apr-75 - Nov-76	0.42	0.25	0.29	0.18	-	0.48	0.37	0.3	0.2	0.2	0.2	0.17
Dec-76 - Mar-77	0.1	0.31	0.26	0.22	0.25	0.14	0.15	0.1	0.1	0.15	0.2	0.17
Apr-77 - Jul-77	0.42	0.28	0.23	0.24	0.10	0.17	0.39	0.4	0.33	0.1	0.15	0.16

BOD (mg/ℓ)

Period	C	D	E	F	F_1	G	H	I	J	K	L	Q
Dec-74 - Mar-75	3.0	5.8	4.4	0.8	0.8	4.2	4.8	4.8	6.8	5.3	5.3	-
Apr-75 - Nov-75	1.5	4.7	4.7	3.2	3.1	2.9	1.3	1.5	1.2	1.1	1.1	1.1
Dec-75 - Mar-76	2.0	8.7	9.6	9.7	9.2	8.4	5.1	4.8	3.9	4.1	3.6	3.1
Apr-76 - Nov-76	0.7	7.0	7.2	6.5	4.4	2.8	1.7	1.2	0.8	.4	.4	.6
Dec-76 - Mar-77	2.65	4.2	7.1	5.3	4.1	4.1	3.0	2.6	3.3	1.8	1.8	2.0
Apr-77 - Jul-77	3.3	3.0	2.9	1.6	1.9	2.8	2.5	2.2	2.2	3.8	3.9	3.5

Conductivity

Period	C	D	E	F	F_1	G	H	I	J	K	L	Q
Jul-75 - Nov-75	1050	1100	940	880	910	890	950	950	890	670	630	940
Dec-75 - Mar-76	1070	940	850	890	930	940	950	1180	930	550	570	950
Apr-76 - Nov-76	1210	1130	900	850	870	760	950	750	880	670	690	1010
Jun-77 - Jul-77	1230	1020	1170	1130	1200	1130	1300	1330	1250	1160	1250	1170

Kjeldahl nitrogen includes all organic nitrogen where the nitrogen is present in reduced form. This includes all proteins and such compounds as urea. Free ammonia will also be included in this measurement. In this study Kjeldahl nitrogen values typically peaked at D which reflected the sewage effluent. Over the project period, the nitrogen decreased probably due to improvements in the Socorro sewage plant. Levels at C above the sewage discharge were higher than expected. It was found that the most likely source was from septic tanks in the area. Generally the KN decreased after station D and then showed another increase in the vicinity of station G located near the feedlot. This was followed by another decrease until at J the levels were quite low. This behavior was more pronounced in the winter months when dilution with irrigation water was not taking place. Some of the increase at G was likely due to absorption of gaseous ammonia; however, the major source was probably runoff from the feedlot. The Kjeldahl assays and some others were affected by input of water from a yet undetermined source. (This will be discussed further in the microbial part.) For the periods of December through March Kjeldahl nitrogen values increased by 10-20% as the water passed by the feedlot. However at station J levels were not high enough to be a problem since dilution in the main diversion ditch is extensive.

Dissolved phosphate was released by the sewer plant in rather large amounts. These were still larger than desireable at J. The feedlot apparently did not contribute significantly to the phosphate load. This is to be expected since phosphate is readily bound to soil and hence is not very mobile.

Dissolved oxygen was lowest at station D. The levels were low enough for sulfide to exist. At J the water was again close to saturation with oxygen. No effect by the feedlot was detected. Redox potentials were measured. The differences between the values at the various sites reflected the difference in dissolved oxygen. Because of this the values are not given in this report..

Nitrate and nitrite ions were found in appreciable quantities at some of the stations. Again as expected the sewer plant was a heavy contributor. There were also increased levels at G, the feedlot, and at stations below this facility. The increase was felt to be partly due to conversion of Kjeldahl nitrogen to nitrate by bacteria. A probable major contibution which showed at stations H and I is subsurface movement of water from the feedlot into the ditch. This water would be high in nitrate.

Ammonia values were often elevated. At first no pattern seemed to be followed. By looking at ammonia volitalized however, the data became more logical. In other words stations very close to the feedlot and on the downwind side tended to absorb gaseous ammonia up to fairly high levels. The results for pH, temperature and conductivity were as expected. pH slowly increased from C through J. Probably caused by groundwater instrusion. Conductivity measurements indicated the Luis Lopez drain increased the salinity of the diversion canal slightly. Most of this "salt" probably came from irrigation water return flows and had little to do with the sewage plant or feedlot.

Biological oxygen demand as expected peaked at D and/or E and generally decreased along the rest of the ditch length. At times after runoff high BOD values were found at G and H. The main contributor was felt to be water passing through stacked manure and leaching soluble organics which ultimately ended up in the ditch.

Boron levels were slightly elevated over what would be preferred. However, they do not appear critical. The levels at D and E peaked on Mondays probably due to extensive washing of clothing on weekends. Fluoride was assayed for, but the values were always between 0.5 and 0.8 ppm and showed no patterns as to site or time of the year.

Sulfide levels were low at all stations except D where concentrations were usually about 3 ppm. This would drop to about 2 ppm at station E and be gone at F.

Sulfate levels showed no trends as to station. Neither did sodium, calcium, potassium or chloride.

Chemical oxygen demand studies gave no basic information as to load on the system.

The ammonia absorption experiments indicated that significant amounts of nitrogen are lost by feedlots and could be reabsorbed by water although around Socorro most probably goes into the atmosphere. In close proximity to the feedlot, sulfuric acid traps averaged absorbing 0.015 grams of ammonia over 2 weeks. The surface area of the traps was 225 cm^2, or about 1/4 ft^2. Converting this to the surface area of an acre gave a figure of about 2.6 Kg ammonia per acre over two weeks or approximately 68 Kg per year. Since boric acid and sulfuric acid greatly enhance the solubility of ammonia as compared to water, these figures should be considered as approximations, although probably in the right range. Water traps were tried, but almost always microbial growth interferred. Control stations located well away showed virtually no ammonia absorption except for one located near the sewage plant. Values here were about 1/10-1/5 that of the feedlot.

Runoff Water

Measureable significant runoff only occurred after rainfall of at least .5 inches. Rainfall of this magnitude generally only takes place in July or August and even then is not common. Usually only 2 or 3 per summer. The following values are for runoff from seven such storms.

Parameter	Ave value	Range
BOD	4,000 mg/ℓ	1,500-12,000
COD	10,000	3,500-16,000
Nitrate - N (as NH_3)	12	1-22
Kjeldahl - N (as NH_3)	220	170-500
Ammonia - N	30	10-40
Phosphate	60	17-80
DO	0.2	0-1

The general nature of rainstorms in the Socorro area during the summer is for heavy rain over a short time. This gives rapid runoff which is short lived and either goes into ponds, into the ground water, or into the drainage ditches. This last can contribute to a severe oxygen deficit as well as furnishing the nitrogen and phosphorus for algal blooms. Attempts to follow this runoff load down stream were not very successful. By the time the runoff peaked the roads in the area are virtually impossible. The only station accessible was J. The pollutants were detectable here, but there was so much mixing due to increased flow in the lower laterals that quantitative data was hard to come by.

Before further discussion of the specific project, some unforeseen difficulties should be mentioned. Some of these besides causing us great problems with assays arise from common local practices which are environmentally unsound.

Adjacent to the research area were many old residences and farms. There is no sewer system available. The waste goes into septic tanks and cesspools. Most of these did not have a drainfield and those that did found the drainfield to be completely saturated. A typical solution is to pump the material from their tanks into irrigation ditches or unto fields. This resulted in high coloform counts as well as elevated nitrogen. This practice should be discouraged, except these individuals feel they have no other solution. Even the commercial tank pumpers acted essentially the same. Twice during the research period, a commercial pumper was observed draining approximately 500 gallons of septic tank material into the Luis Lopez drain. It would seem that this should be illegal.

Other difficulties were caused by the Socorro sewer plant. For a time this plant was dumping untreated sewage into the drain during a plant breakdown. Later they used so much chlorine, that residual amounts were still detectable at station E. This caused difficulties with several assays. However, over the last year or so, the Socorro plant appears to be doing an excellent job and has been most cooperative.

Conclusions and Recommendations

The effects on the Luis Lopez drain and the water in the main diversion canal caused by the sewage plant and the feedlot do not appear to be severe. If the water in the main canal was of higher quality this would not be true. However, it already contained appreciable amounts of contaminants and the percentage of further degradation by the drain was not large. Only after heavy rainfall were amounts of pollutants from the feedlot potentially harmful. Under the usual "steady state", the drain dissolves sufficient oxygen to reduce the BOD and to convert Kjeldahl nitrogen to nitrate. A significant amount of the nitrogen from the feedlot is lost as ammonia. This is probably a much higher fraction in an arid environment than it would be in a moister climate. This volatile ammonia appears to present no hazard as it is rapidly diluted by air or absorbed by water.

The major hazard would be from runoff after heavy storms. For any environmentally sound feedlot, the runoff should be controlled or contained. For New Mexico the best solution would seem to be to grade and slope the lot and any areas where manure is piled to drain into either a natural depression or a constructed lagoon. This lagoon should be large enough to hold runoff for one year. Soil permeability would rarely be a problem as the precipitation of salts would tend to seal the lagoon bottom. In the presence of the available nutrients, the lower pond levels should tend to be anaerobic allowing for conversion of nitrates etc. to nitrogen gas. Phosphates would be trapped in the pond and remain in the area. We feel all new feedlots should include such a lagoon in their plan before permits are issued and old feedlots should do this within a reasonable time.

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Microbiological Study

Introduction

It was the purpose of this study to use methods of bacterial enumeration and identification in order to determine sources of water-quality modifiers of channel water of the Rio Grande in central New Mexico. Of particular concern were the Socorro sewage treatment plant, runoff from agricultural land, and runoff from a feedlot. An attempt was made to associate bacterial population number and type in channel water with these particular potential or real sources of pollutants.

Materials and Methods

Sampling. Water samples were collected in sterile 250-ml polypropylene bottles. The samples were either processed immediately for determination of bacterial-cell concentration or stored at 3 to 4°C for no more than 24 hours following collection prior to analysis.

Bacterial Cell Numbers. Samples were diluted in distilled water with 0.5% peptone (Standard Methods, 1971), and cell counts were determined by using the pour plate procedure; counts from duplicate plates were averaged. Total counts of heterotrophic, mesophilic bacteria were determined with the BBL Standard Methods Agar (No. 11638) incubated at 20°C for five days. The count of total coliform bacteria originating from the soil and fecal sources was determined with the BBL Endo Agar (No. 11199) incubated at 35°C for 48 hours. The count of coliforms growing at 44.5°C incubation after 48 hours, considered fecal coliforms, was also determined using BBL Endo Agar. Streptococcal populations were determined using BBL M-Enterococcus Agar (No. 11213), KF Streptococcal Agar (No. 11313), and Enterococcosel Broth (No. 12206) solidified with 1.5% BBL Agar (No. 11849) incubated at 35°C for 48 hours.

Bacterial Identification. Randomly selected colonies were picked from the plates for coliform and streptococci numbers determination. The colonies were transferred to BBL Trypticose Soy Agar (No. 11043) slants in screw-cap culture tubes. These cultures were used for Gram stains and subsequent tests for identification. Differentiation of the coliform-type microbes was based upon the "IMViC" reactions separating the group into types considered as originating from soil or feces and intermediate types (Geldreich, 1966). The streptococci were differentiated on the basis of the scheme reported by Geldreich and Kenner (1966).

Results and Discussion

The numbers of microbes present in the water which grow on Standard Methods Agar medium representing a "total" count (Table 1) are of the range reported for a previous study of similar water (Brierley et. al., 1975). No significant trends occur in the counts. A small increase in the cell concentration was noted for the water passing near the feedlot (between samples F and G). However, the increase was not consistently observed and cannot be specifically attributed to the feedlot presence.

Table 1

Standard Plate Count

Sample Date	Sample location - colony count ml^{-1}					
	C	D	F	G	K	L
2- 2-77	1.1×10^{5}	9.3×10^{5}	1.7×10^{5}	1.1×10^{5}	2.0×10^{5}	2.4×10^{5}
3- 9-77	2.8×10^{4}	4.6×10^{5}	1.7×10^{4}	5.0×10^{5}	1.2×10^{5}	3.2×10^{5}
4- 5-77	5.0×10^{3}	3.5×10^{3}	2.0×10^{5}	2.3×10^{5}	2.3×10^{5}	2.2×10^{5}
4-27-77	1.5×10^{4}	9.5×10^{3}	5.6×10^{4}	6.2×10^{4}	2.0×10^{3}	6.5×10^{3}
5- 4-77	9.6×10^{3}	3.2×10^{4}	4.1×10^{4}	2.8×10^{4}	1.6×10^{3}	1.3×10^{3}
6- 1-77	2.1×10^{4}	1.0×10^{5}	5.4×10^{4}	5.7×10^{4}	2.5×10^{4}	4.7×10^{4}
7-12-77	2.9×10^{4}	1.1×10^{4}	1.5×10^{6}	1.6×10^{6}	2.4×10^{4}	1.0×10^{6}
8-24-77	3.6×10^{4}	1.0×10^{4}	8.7×10^{4}	9.5×10^{4}	7.0×10^{3}	1.3×10^{4}

The results of total and fecal coliform analyses are presented in Tables 2 and 3 respectively.

Table 2

Total Coliform Count

Sample Date	Sample location - colony count ml^{-1}					
	C	D	F	G	K	L
2- 2-77	5.6×10^{1}	<1	5.6×10^{1}	6.8×10^{1}	1.2×10^{1}	1.4×10^{1}
3- 9-77	4	1	8	2.0×10^{1}	1.1×10^{1}	8
4- 5-77	1	<1	1.4×10^{2}	1.6×10^{2}	1.4×10^{2}	9.6×10^{1}
4-27-77	1.7×10^{2}	6	5.6×10^{1}	5.6×10^{1}	2.5×10^{1}	7.5×10^{1}
5- 4-77	1.1×10^{2}	4.6×10^{3}	6.9×10^{2}	1.1×10^{3}	5.6×10^{1}	4.4×10^{1}
6- 1-77	1.9×10^{2}	1.9×10^{3}	5.9×10^{2}	3.0×10^{2}	5	1.2×10^{1}
7-12-77	2.3×10^{2}	7.2×10^{1}	2.6×10^{4}	2.8×10^{4}	1.1×10^{2}	8.1×10^{3}
8-24-77	3.7×10^{2}	1.9×10^{2}	1.9×10^{3}	5.0×10^{3}	2.0×10^{2}	1.2×10^{2}

Table 3

Fecal Coliform Count

Sample Date		Sample location - colony count ml^{-1}				
	C	D	F	G	K	L
2- 2-77	3	<1	6	1	3	3
3- 9-77	<1	<1	3	1	3	5
4- 5-77	<1	<1	<1	<1	2	1
4-27-77	3.6×10^1	1	4.9×10^1	5.5×10^1	3	8
5- 4-77	5	9.7×10^2	4.3×10^1	1.1×10^1	5.0×10^1	1.3×10^1
6- 1-77	7.7×10^1	6.2×10^2	3.3×10^2	4.0×10^2	3	4
7-12-77	1.3×10^2	1.4×10^1	6.5×10^3	5.7×10^3	6.1×10^1	2.9×10^3
8-24-77	8	<1	1.2×10^1	1.6×10^1	<1	<1

There is little change in either the total coliform count or fecal coliform count in the ditch water flowing past the feedlot from station F to G. There appears to be no continual drainage from this area into the ditch. The low counts of coliforms at station D reflect the effect of chlorination of the sewage effluent from the Socorro municipal treatment plant. The sudden increase in both total- and fecal-coliforms at sampling station D was a result of problems at the sewage treatment plant preventing adequate treatment and chlorination. The coliform counts increased between stations D and F during the July and August sampling dates. Inspection of the Luis Lopez ditch revealed an agricultural drain effluent entering. It is believed that this drain, running during the irrigation season, is responsible for the increased counts and may be receiving raw sewage. The coliform count indicate little impact of the Luis Lopez drain on the BLM Low-Flow Channel as indicated by little change in count between stations K and L.

The results of the count of streptococci present in the water samples is presented in Table 4. These results also suggest that there is no constant drainage from the feedlot between stations F and G. The problems developing at the Socorro sewage treatment plant during May and June are clearly indicated by the increase in streptococci at station D. The streptococci count also clearly indicate a source of pollution between stations D and F as shown by the coliform count data (Tables 2 and 3). Only for the July sample did the Luis Lopez ditch appear to affect the streptococci count in the BLM Low-Flow Channel at station L.

Table 4

Streptococcal Count

Sample Date	Sample location - colony count ml^{-1}						
	C	D	F	G	K	L	Medium
2- 2-77	3	<1	3	<1	1.7×10^1	1.9×10^1	M[1]
	5	<1	5	2	1.2×10^1	1.6×10^1	KF[2]
3- 9-77	2	<1	3	1	<1	1	M
	2	<1	8	7	5	4	KF
4- 5-77	<1	<1	2	<1	<1	1	M
	1	<1	2	2	3	3	KF
5- 4-77	<1	5.6×10^1	2	2	<1	<1	M
	1	5.1×10^1	<1	3	1	4	KF
6- 1-77	6	9.2×10^1	1.4×10^1	1.2×10^1	4	3	M
	2	1.0×10^2	8	4	2	8	KF
7-12-77	1.6×10^1	<1	6.0×10^1	7.6×10^1	<1	1.4×10^1	M
	1.1×10^1	<1	9.9×10^1	9.0×10^1	<1	2.7×10^1	KF
	9	<1	7.2×10^1	8.5×10^1	<1	1.7×10^1	EC[3]
8-24-77	8	<1	3.5×10^1	4.4×10^1	<1	<1	M
	1.0×10^1	<1	6.0×10^1	6.3×10^1	<1	<1	KF

[1] M = M-Enterococcus Agar
[2] KF= KF-Streptococcal Agar
[3] EC= Enterococcosel Agar

At this time, the channel contained little water and the ditch was adding a large proportion of the total flowing water.

Several media were compared for use in obtaining streptococci counts (Table 4). Little difference in counts occurred regardless of M-Enterococcus Agar KF-Streptococcal Agar or, in one case, Enterococcosel Agar were used.

Randomly chosen colonies from the total coliform agar plates were selected and characterized regarding type i.e. whether they were fecal, soil or intermediate forms. The results are presented in Table 5. One hundred twenty eight colonies were selected and included 39.8% fecal coliforms, 19.5% soil coliforms with 40.6% intermediate type coliforms. The method of selection does not allow for interpretation of significance relative to each sampling station. However, fecal coliforms can be found at all stations sampled.

Table 5

Coliform Type Identification

Date	Sample	No. Colonies Examined	No. Coliform Types		
			Fecal	Soil	Inermediate
2- 2-77	F	9	4	0	5
	G	4	4	0	0
	K	2	1	0	1
3- 9-77	C	1	0	0	1
	F	2	1	1	0
	G	3	1	2	0
	K	2	1	0	1
	L	5	1	0	4
4- 5-77	C	1	0	1	0
	F	6	4	2	0
	G	2	1	0	1
	K	4	0	0	4
	L	3	0	0	3
4-27-77	C	7	6	1	0
	D	2	1	0	1
	F	6	4	2	0
	G	1	1	0	0
5- 4-77	C	2	2	0	0
	D	3	2	1	0
	F	4	1	0	3
	G	5	3	1	1
6- 1-77	C	5	1	4	0
	D	3	1	0	2
	F	5	1	2	2
	G	5	2	1	2
	L	1	0	0	1
7-12-77	C	3	0	1	2
	D	5	1	3	1
	F	4	0	1	3
	G	2	0	0	2
	K	4	0	0	4
	L	2	0	0	2
8-29-77	C	4	4	0	0
	D	4	0	1	3
	F	3	2	0	1
	G	2	1	0	1
	K	1	0	0	1
	L	1	0	1	0
Total		128	51	25	52
%			39.8	19.5	40.6

A similar analysis was performed to identify possible sources of the streptococci (Table 6). The streptococci indicative of their respective sources were Streptococcus faecalis var liquefaciens, insect source; enterococci, warm-blooded animal source; and S. bovis and S. equinus, livestock and pultry source. Of 94 randomly selected colonies, the largest percentage (68.1%) was represented by enterococci believed to have come from a warm blooded animal source, and they were found in samples from all stations.

Table 6

Streptococci Source Identification

Date	Sample	No. Colonies Examined	Insect	Warm Blooded Animal	Livestock	Unknown
2- 2-77	F	11	0	6	0	5
	G	1	0	1	0	0
	K	4	0	3	1	0
3- 9-77	C	3	0	2	0	1
	F	5	0	3	0	2
	G	5	0	4	0	1
	K	1	0	0	0	1
	L	2	0	1	0	1
4- 5-77	F	5	0	5	0	0
	G	2	0	2	0	0
	K	2	0	1	0	1
	L	2	0	1	0	1
5- 4-77	D	2	0	2	0	0
	F	2	0	2	0	0
6- 1-77	C	1	0	1	0	0
	D	5	0	2	0	3
	F	3	0	1	0	2
	G	3	0	1	0	2
	K	3	0	1	1	1
7-12-77	C	6	1	5	0	0
	F	3	0	3	0	0
	G	5	1	3	0	1
	L	5	0	5	0	0
8-29-77	C	4	1	3	0	0
	F	5	0	3	0	2
	G	4	0	3	0	1
Total		94	3	64	2	25
%			3.2	68.1	2.1	26.6

Only samples from station K had streptococci indicating a livestock source, none were found in samples of water near the feedlot. Caution is given in interpretation of this data indicating little pollution associated with livestock as the colony selection procedure may missed these types of indicators. Also, the microbes S. bovis and S. equinus are not long lasting in the aquatic environment and are only indicators of a recent pollution condition (Geldreich and Kenner, 1969). Determination of types and sources of streptococci does not indicate any further deterioration of the water "quality" attributable to the feedlot operation.

The most significant modifiers of the ditch water of the sampling area as determined by microbial populations appear to be the Socorro sewage treatment plant during periods of improper operation and undefined source(s) associated with an agricultural drain. Poorly treated municipal sewage and agricultural drain water contain similar patterns of microorganisms when the stated procedures are used. It does not appear possible, with these methods, to differentiate the sources. It is possible that there is a source (or sources) of untreated sewage discharging into the agriculture drain providing a microbial population similar to municipal sewage.

Bibliography

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