Response of New Zealand Rabbits to Drinking Water Treated with Alum and PolyDADMAC

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ABSTRACT

PolyDADMAC (Polydiallyl-Dimethyl Ammonium Chloride) and Alum (Aluminium Sulphate) were the chemical agents used for potable water flocculation in Khartoum State. The response of New Zealand rabbits to drinking water treated with alum and polyDADMAC in terms of serum changes in electrolytes was studied. Six New Zealand rabbits of balanced sexes were purchased, clinically adapted for two weeks and divided into 2 groups, control (group 1) and test (group 2). The test group was orally given a dose of 1% polyDADMAC and 1% alum in a blend ratio of 1:2, respectively, for an experimental period of 10 weeks. Test chemicals blend was similar to the dose applied by Khartoum Water Plant, during flood season, for human consumption. Sera were analyzed for electrolytes prior to the experiment and, thereafter, at weekly intervals. Serum calcium, phosphorus, iron and magnesium levels showed remarkable (P≤ 0.01 - 0.001) decreases compared to the control, the fact which can be attributed to the hepatic damage induced by test chemicals. Sodium and potassium levels were not determined. The test group had significantly (P≤ 0.01) low iron that can be attributed to the direct effect of alum. Intestinal wall with spotted white colour (probably due to alum causing focal enteritis), was greatly affected with the irritant alum and/or its metabolites. When the ion-exchanged resin was used to remove poisons from water, it precipitated by alum. It is more apt to gripe; the salt intensifies the action of resin and hence produces the hydragogue effect. This action was very clear in the congested mesenteric blood vessels and was symptomatically manifested by diarrhoea and salivation due to nausea. Alum and polyDADMAC which are currently used in potable water treatment in Khartoum State, proved toxic to New Zealand rabbits in terms of changes in electrolytes coupled with enteropathies.

Key words: Alum; PolyDADMAC; clinical signs; electrolytes; toxicity

INTRODUCTION

Urban clean-water needs became today a necessity with an increasing population. The urban efforts to secure, purify or transport water indulge pollution.
Khartoum State Water Corporation (1925) owns many River Nile water purification stations to fulfill the needs of the capital especially during the flood season (Idris, 2000). Alum (Aluminium sulphate) was the first chemical element used to reduce the turbidity of the Nile water with a maximum allowable level (MAL) of 150 mg/l. Throughout time, alum did not give satisfactory results with the increasing domestic water need, and hence, there was search for an efficient water flocculent as an alternative.

In 1997, the organic polyelectrolyte polymer polyDADMAC (Polydiallyl-Dimethyl Ammonium Chloride) was put on trial, and in 1999 was ratified as a regular flocculent (in partial blend with alum), raising a lot of controversy. Although this polymer category is an SNF certified one (SNF, 2000), still its approval for use is factory specific. Though much information was missing in the product data sheet like the maximum use level, per cent carry-over monomer and stability, health effects and toxicity likewise were not focused for both man and animals. The objective of this experiment was to reveal the response of New Zealand rabbits to drinking water treatment with alum and polyDADMAC blend in terms of serum changes in electrolytes.

**MATERIALS AND METHODS**

**Animals and grouping**

Six, 5-7 months old, clinically healthy New Zealand rabbits of balanced sex, were purchased from Balsam Pharmaceutical Laboratories, and within the premises of the Department of Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Khartoum (Fig. 1). Rabbits were rested, ear tagged and received prophylactic doses of Oxytetracycline 5% (Bremerpharma, Germany) and Sulphamethazine 33.3% (Norbrook, UK) against bacterial infections and coccidiosis, respectively. The rabbits were given a 2-week adaptation period during which Lucerne was fed and Nile drinking water was provided ad libitum. Animals were weighed and distributed into two groups (2x3) as control (G 1) and test (G 2).

**Administration of dosages**

Test chemicals, polyDADMAC and alum (AlSO$_4$), were obtained from Khartoum Water Corporation (El Mugran Station) and prepared in separate stocks each as 1% solution. The two test solutions were blended at 1:2 of the polymer and alum, respectively, similar to the dose applied by Khartoum Water Plant, during flood season, for human consumption. Test blend was daily watered ad libitum to rabbits of group 2 in drinking Nile water. The untreated controls were put on Nile water. Watering continued for 10 weeks.

**Data collected**
Clinical signs and mortalities were daily recorded. Blood samples were collected from the ear vein of rabbits before and weekly after dosing with the test blended solution for serum (Schalm, 1965) determination of macrominerals Ca, K, Na and P using commercial kits (Cornellius and Kaneko, 1963). Serum trace elements Fe and Mn were determined using atomic absorption spectrometry (Sperling and Welz, 1999). At necropsy or in extremis slaughter, the rabbits were examined for gross lesions and samples of vital organs intestine, liver, kidneys, heart and lungs were immediately fixed in 10% neutral buffered formalin and paraffin sections were stained with haematoxylin and eosin (H&E).

**Statistical verifications**

Mean values obtained in serum macro and microminerals were statistically verified using the un-paired Student t-test. All means were compared at the 1 or 0.1% probability level (Snedecor and Cochran, 1989).

**RESULTS**

**Clinical signs and mortality**

Rabbits of the test group 2 were off food suffering from salivation, vomiting and diarrhoea. They were moving noticeably slowly and finally they showed hind limb paralysis. The mortality rate was 100%. Rabbits of the undosed control (Group 1) were normal.

**Changes in serum electrolytes**

Serum levels of Mg, Fe, Ca and P showed significant (P ≤ 0.0, P ≤ 0.001) decreases compared to the un-dosed control rabbits. Sodium and potassium levels were not determined.

**Postmortem changes**

The lungs of the rabbits of group 2 showed adhesions, congestions and haemorrhages. Intestinal and stomach flatulence were also obvious. Intestinal wall showed white spots. Cardiac, renal and liver congestions were sometimes accompanied by haemorrhages. Rabbits of group 1 showed a normal scene in response to drinking the dose-free water.

**Histopathology**

In the livers of rabbits of group 2 necrosis, haemorrhages and lymphocyte infiltrations were clearly seen. In the lungs emphysema (Fig. 2) and lymphocyte infiltrations were clear. Intestinal congestion of blood vessels and deposition of
haemosiderin in the spleen (Fig. 3) were characteristic. Severe necrosis and haemorrhages of cortex and medulla and shrinkage of glomeruli were seen in the kidney (Fig. 4). Normal tissues were seen on the slide pictures of group 1 rabbits (undosed controls).

**DISCUSSION**

In this study, the slow movement, hind limb was mostly pertinent to the stimulation of the central nervous system (CNS) suggesting inhibition of the serum cholinesterase activity which was not, unfortunately, measured leading to abnormal posture and gait and nervous signs due to the action of the organochloride as a diffuse stimulant of the CNS. (Clarke, 1975 and Mohamed, 1987). This can also be attributed to the significant change in electrolytes. This may lead in some instances to muscle shivering, tremors and paralysis especially if accompanied by the miscellaneous polymer effects indicated by the significant decreases in some macro and microminerals. These electrolytes have effects on muscle action, potential and eventual spasms (Underwood, 1977 and Ganong, 2003). In current study, test serum levels of Mg, Fe, Ca and P showed significant ($P \leq 0.01-0.001$) decreases compared to the un-dosed control rabbits, the fact which can be attributed to the hepatic damage induced by the test chemicals (Cornellius and Kaneko, 1963) and the test group, significant ($P \leq 0.01$) low iron, can be attributed to the direct effect of alum (Clarke, 1975).

The lungs of the rabbits of group 2 adhesions, congestions, haemorrhages and lymphocyte infiltrations were clear. These pulmonary disorders may be attributed to the direct irritant action of the blend as whole or alum alone. Severe congestions, haemorrhages of cortex and medulla, shrinkage of glomeruli and renal focal areas of necrosis may be attributed to renal damage due to the severe decrease in electrolytes (Ford, 1963).

When the ion-exchanged resin, used to remove poisons from water, is precipitated by alum in its test preparation, it is more apt to gripe. Commonly, the salt intensifies the action of resin and hence produces the hydragogue effect. This action was clear on the congested mesenteric blood vessels and symptomatically manifested by nausea salivation and diarrhoea. Intestinal wall was spotted with white i.e. was greatly affected with the irritant alum and/or its metabolites, probably causing focal enteritis.

**Conclusion**

Alum and polyDADMAC currently used flocculation doses for potable water treatment in Khartoum State, proved toxic to Newzealand rabbits in terms of changes in electrolytes coupled with enteropathies.

**REFERENCES**


Table 1. Mean (± S.D.) values of serum electrolytes of rabbits watered 1% solutions of polyDADMAC and alumin 1:2 blend, respectively

<table>
<thead>
<tr>
<th>Group/Dose</th>
<th>Mg</th>
<th>Iron</th>
<th>Na</th>
<th>K</th>
<th>Ca</th>
<th>P</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>mg/dl</td>
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<tr>
<td>G₁ (Undosed)</td>
<td>1.56±0.17</td>
<td>256.28±39.81</td>
<td>7.70±3.23</td>
<td>1.97±1.22</td>
<td>11.38±0.99</td>
<td>4.34±0.13</td>
</tr>
<tr>
<td>G₂ (1:2 solution)</td>
<td>0.39±0.42**</td>
<td>35.93±9.50**</td>
<td>ND</td>
<td>ND</td>
<td>3.17±0.67**</td>
<td>1.52±0.09***</td>
</tr>
</tbody>
</table>

ND = Not determined  ** (P≤ 0.01)  *** (P≤0.001)

Fig. 1. Experimental rabbits housing
Fig. 2. Lung emphyseaema in a rabbit of group 2 dosed with combined 1% alum and 1% polymer in drinking water. X100

Fig. 3. Haemosiderin deposition in the spleen of rabbits of group 2 dosed with combined 1% alum and 1% polymer in drinking water. X100
Fig. 4. Necrosis in the glomeruli and haemorrhage in the tubules of a rabbit dosed with combined 1% alum and 1% polymer in drinking water. X100