2003 SCHOLARSHIP REPORT

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Topic: Water Medication for Livestock Production

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Table of Contents

# Executive Summary

Studying water medication has taken me to nine countries around the world only to find that Australia leads the way. No matter where we may farm it's tough; short growing seasons, prolonged winters, harsh summers and variable climate, short day light hours, infertile soils, animal welfare issues, world trade tariff barriers, customer perception and demands all impact on our business.

As a result of my scholarship, and in parallel, an intensive review of water medication was conducted by Meat and Livestock Australia. My report addresses many issues and is intended as a guide to other producers considering the implementation of a water medication system.

Water medication has been an alternative in feeding nutrients to livestock for over 35 years and developments in the last decade with equipment, technology and adoption of the system has resulted in many producers using this management tool.

Water medication is the supplying of dissolved nutrients that have been mechanically administered into the drinking water at a calculated dosage to supplement and enhance animal requirements.

Water medication does work and it can be a very cost effective supplementation method for feeding NPN (Non Protein Nitrogen) and other nutrients. Strategic feeding of supplement can greatly improve the performance of livestock and maximise pasture utilisation low in nutrients. In Northern Australia's native and improved pastures the major limiting nutrients are protein and energy in the dry/winter season and Phosphorus (P) in the summer/wet season. When livestock producers are using water medication to feed supplement they need to be aware of the water quality issues, the chemical interaction between what products they are mixing and the water they are using, the solubility of the products, the sheeting or striping and absorption characteristics of products. All these factors greatly affect the efficiency of the supplementation method when diluting and feeding to livestock. Producers also need to be aware of commercial biases and misleading information.

My recommendation to anyone who is using or intending to use water medication is:- research what you want to achieve, analyse your resources and monitor your results. Be prepared to change and be prepared to shut the system down from time to time to get up to speed with new developments.

## Acknowledgments

I wish to acknowledge first and foremost my wife, Helen for the way in which she managed sometimes difficult situations and solved problems in my absence, then our two children, Adam & Chelsea for their support. Also close friends and supporters, the Taylor, Mackenzie, Cox and Williams families and lastly my late father for his support and counsel to Helen during the time I was away.

To the *Sylvia & Charles Viertel Charitable Foundation*, I appreciate the support and opportunity they presented by sponsoring my scholarship, without which, this life changing experience would not have been possible.

Dr Sandi Jephcott for the information she provided and the time she made available for telephone consultation.

Assistance from Rabobank regional manager Craig Swalling Longreach office, Rabobank International Netherlands Geohart Wessiner and Emma Carby Brown and Rabobank International New York based Fiona Boules.

There were numerous ways in which people assisted me, not always directly, related to my study topic, The Nuffield Scholars around the world who have helped me on my study tour including Nuffield Scholars in the UK, Wes & Alison Ewing, Liz Bowles & John Stones.

Meat & Livestock Australia (Northern Beef Program), Dr Wayne Hall, Peter Loneragan & Dr Geoff Neithe.

Keith Entwistle Armidale NSW, Keith Hall DPI Alice Springs, Désirée Jackson DPI Longreach, Western Qld Beef Research Committee Members (2003) .

I wish to say thank you to all the above mentioned and to the unknown friendly helpers who offered friendship and assistance whilst travelling in foreign countries, negotiating travel and direction while en route it was greatly appreciated.

## Aims\Objectives\Study Goals.

My aims were simple enough, that is to visit as many countries as I could with what funds I had available. Also to get exposure to as many different businesses, enterprises, topics and characters as possible while sorting quality from quantity.

My objectives were and still are to develop defendable management practices based on global best practice principals.

## Background:

In this report the author has detailed and documented information mainly researched here in Australia.

The scholar visited the Netherlands, Norway, Canada, UK and the USA studying supplementation and the feeding of nutrition to livestock. Although the countries visited are geographically very different to Northern Australia the scholar reports the following issues to be noted. Northern Australia is a grass based system which is produced from summer rains but we have extended periods of low protein and nutrient deficient pastures. With the capping, piping and water system development of the great artesian basin many producers are considering variable alternatives and improved cost effective methods of supplementation.

In contrast the northern hemisphere's low temperature and low water intake makes the consumption of diluted additive in high concentration rates difficult. The farmers feed livestock that are shedded for up to eight months of the year. The livestock are fed silage and various feed additives. The feeding of Non-Protein Nitrogen (Urea) is non-existent.

The purpose of this report is to highlight to producers considering either implementing a water medication system or those who are already using this system, how to improve and question why they are doing certain things.

Water medication does work, but it can be and is greatly affected by water quality and its chemical reaction with additives diluted in it.

Together with my wife Helen, we own and operate a beef cattle business in Western Qld. I am not university educated but thanks to a Nuffield Scholarship I have been assisted to be *universally* educated. I have been an industry representative at regional, state and national levels. I have had reasonable exposure to industry organisations, issues and as an industry representative. In 1996 I received a scholarship to travel to the USA and Canada, studying cattle grazing management and production systems. In nine weeks I visited twelve ranches in the mid west region from Texas to Alberta in Canada.

Our passion is continued education and our goal is to produce more beef from the pasture we have available and to ourselves, adopting best practice management. My interest in animal nutrition and beef production has been pivotal to the survival of our beef enterprise. Lowering the cost of production and improving efficiency in pasture utilisation are essential to our survival in the beef industry. All this has led us to install a watering system covering our property and equipping this system with a water medicator as have numerous other producers in Northern Australia. This has given positive benefits, however it also has consumed a lot of time, money and resources improving and perfecting the system.

Western Queensland has a great underground water resource in the great artesian basin. Numerous bores tap into the sub artesian and the artesian basin, over the years many bores have and are currently being reconditioned. This involves re-casing the bore hole, capping the water flow and piping the water to watering points. This improves the water use efficiency by a ratio of a 100:1. The piping of water and controlled watering has provided an opportunity for producers to equip these systems with water medicators, feeding urea and trace elements cost effectively to livestock.

Water supplementation has huge potential in Queensland, Northern Territory, and Western Australia as 50% of Australia's cattle numbers are in Northern Australia.

Small increments of improvements in production are worth millions of dollars to the bottom line of beef producers collectively.

The extended interest was sparked by the numerous inquiries from producers through the Western Qld Regional Beef Research Committee during the time I was associated with it. So running in parallel but totally independent to my study has been an extensive review of water medication conducted by Meat & Livestock Australia.

My Nuffield tour has taken me to nine countries around the world, I have met with many people and shared great hospitality and good cheer. In putting this report together, I elected to cover mainly what is happening here in Australia and the issues we face, thus providing what I hope is a document for an introduction and reference to water medication.

# Introduction

Natural grass production systems are the largest and the most cost effective means of beef production in Australia. The cost to develop and maintain these systems is enormous but grass remains the largest and cheapest source of cattle feed in Australia, and the basis on which the beef industry in this country was developed and is maintained. In contrast to many other parts of the world, Australian beef cattle spend the majority of their life in a grazing situation. This is also true for Australian cattle that eventually enter feedlots for final finishing.

To make the most efficient use of this feed supply and to optimise cattle production, available nutrition needs to be managed to fit the varying requirements of animals at different stages of their life. In summary, **available nutrient supply needs to match nutrient demands.**

There are a number of ways to manage the supply and demand equation. **Strategic supplementation strategies** are widely used, and these aim to supply nutrients that are lacking in pasture, for example protein or phosphorus.

However supplementation should not be seen as the only approach to nutritional management. There are a number of other management options, early weaning, controlled mating and segregation of breeders (particularly heifers) according to nutrient requirements are examples. These strategies will also assist to reduce the gap between nutrient supply from pasture and nutrient requirements, and will help to improve production levels.

Traditional supplement delivery methods have included loose dry lick mixes consisting of non-protein nitrogen sources such as urea, protein meals and minerals such as phosphorus and salt liquid supplements such as urea and molasses, or commercial mixes eg Anipro, Prolix, lick blocks containing a wide variety of components.

However for some of these traditional supplementation systems, irregular and variable supplement intakes have meant that responses have not always been uniform, or as good as expected, since some animals over-consume, some under-consume, and others reject the supplement. The ultimate consequences of irregular and variable supplement intakes are poor efficiency of utilisation, responses that are lower than expected and higher supplementation costs.

Supplement consumption patterns are determined by **animal behaviour factors**, such as previous experience of supplements, dominance, temperament and shy feeders, **supplement factors,** such as palatability and/or poor attractiveness and lick-block hardness, **soil and pasture deficiencies** of certain attractant minerals such as phosphorus and sodium which cattle will actively seek out, **management factors** such as location of supplements in the paddock**,** available trough space and construction of troughs.

Animals have to drink water, and they do so in amounts relative to their size, their metabolic requirements, the moisture content of the feed and the climatic conditions. Knowing this, a number of producers and scientists developed the idea that if supplements could be incorporated in water, then they would be consumed at the correct levels by all animals that drank the treated water. This approach was first tried in the 1970's. The technology used then experienced some problems. There were occasional mortalities with urea-based supplements due to excess urea being added to the water. In other cases there was poor performance when some crude forms of phosphorus supplements were fed. These problems led to a loss of interest by many producers in the supply of nutrients through the water.

In the last 10 years however, a number of more reliable and safer water medicators have been developed for administration of soluble nutrients in the water. Better or more appropriate supplements have also been identified. Consequently, where water sources can be controlled and alternate watering points were not located in paddocks, producers have successfully installed water medicators to provide critical limiting nutrients to grazing cattle. The adoption of this technology has not been widespread, as it is not suitable for all situations, particularly where water is of poor quality and also where there are concerns by producers regarding safety, reliability and costs of water medication.

On-going technological developments will probably lead to better, safer and more user-friendly medicator units as well as alternate and better supplement formulations. However some of the basic principles of application and use are unlikely to change.

One of the critical areas of improvement will be a better understanding of water quality issues, how these can be better monitored, how water quality interacts with supplement delivery, and how the water can be effectively changed or modified to improve efficiency of delivery of water based supplements.

Some frequently asked questions on water medication:

## *Safety Issues*

How safe is the technology, and what should I do to minimise toxicity problems? ***(Sections 2,5,7)***

What monitoring tools will I need or are available to help with safety? ***(Section 2,5)***

## *Technical Information*

How does it work? - the technical information ***(Section 5)***

Will it work in my watering system? ***(Sections 4,5,7)***

How much does it cost to purchase and set up medicators and what is the comparative cost between water supplementation and dry lick? ***(Sections 5,6)***

How much time does it take to operate the water medicator and keep the supplement at a productive level? ***(Sections 5,6,7)***

## *Supplements*

What are the things I need to know to be sure my stock are getting the correct doses of supplements? How can we simplify the calculations? ***(Sections 2,5,6)***

What supplements should I use in the water and why? ***(Sections 2,6)***

Are there any sources of energy or other nutrients not traditionally used in supplements that can be used through the water ***(Sections 2,6)***

Can I use medicators together with dry licks? ***(Sections 5,6,7)***

## *Water Quality*

Will it affect the water intake of my stock? ***(Sections 3,4,5)***

How can I assess water quality and how do I interpret lab reports on quality? ***(Section 4)***

Will medicators work when bore waters are of poor quality? If so, how do I modify the water quality to maximise the benefit of water medication? ***(Sections 4,5)***

# SECTION 2. A BRIEF OVERVIEW OF RUMINANT NUTRITION

One of the key principles to understanding animal nutrition is the principle of **the primary limiting nutrient.** The supply of nutrients other than the primary limiting nutrient will have no effect on performance until that primary deficiency is corrected. Lack of attention to this simple principle is probably the major cause of economic wastage related to supplementary feeding. Targeting the primary limiting nutrient is the priority for a cost-efficient supplementation program.

In northern Australia's native and improved pastures, the **major limiting nutrients** are **protein** and **energy** in the dry/winter season and **phosphorus** (P) in the summer/wet season.

Protein deficiencies are usually rectified by protein meals or non-protein nitrogen (NPN) sources such as urea. Urea can be delivered in lick mixes, blocks or in the water. Rectifying protein deficiency usually leads to an increase in pasture intake, which partly rectifies the energy deficiency.

Phosphorus can be delivered by a range of methods including dry licks and blocks as well as by water medication, depending on water quality.

*Ruminant digestive system structure and function*

Ruminants have evolved a specialist digestive system enabling them to utilise high-fibre diets such as grass. They do this by forming a symbiotic relationship with fibre-digesting micro-organisms in sections of the digestive tract. The animal provides the home (rumen) and harvests the forage; the microbes digest the forage to supply the nutrients for their own growth and reproduction. Nutrients that are not utilised by microbes, and the microbes themselves, in turn supply nutrients for the animal's growth and reproduction.

## Mouth

During harvesting and chewing, pasture is reduced to 1-5cm lengths. While chewing their food ('chewing the cud'-ruminating), cattle produce copious amounts of saliva. The amount of saliva is related to the type of diet, especially the roughage content. When grazing high roughage diets cattle will produce in excess of 140L of saliva per day. Much of this is absorbed as water and recycled, thus roughage quality and water intake are related but not directly correlated.

Saliva contains significant quantities of various salts (sodium, potassium, phosphates, chlorides and bicarbonate), which aid in maintaining rumen pH at the desirable level. Rumen pH for cattle on pasture is 6 to 7, and for cattle on concentrate feeds is 5.5 to 6.5. Rumen pH <5 indicates acidosis and >7 indicates anorexia or 'dead belly'.

Once the animal has satisfied its appetite it will ruminate, further decreasing the size of the pieces and so increasing the surface area of the food particles on which the rumen micro-organisms can act.

Food passes from the mouth via the oesophagus (gullet) to the stomach, which is divided into four compartments that have different functions. The location, relative size and functions of the four stomachs of cattle are shown in Figure 1.

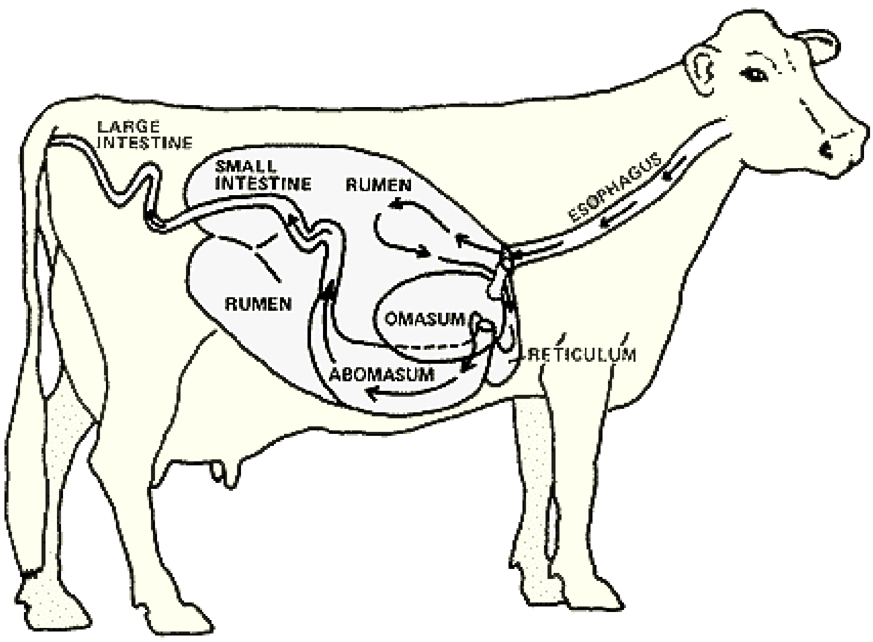
## Rumen and Reticulum

The first two compartments of the stomach, the rumen or paunch (about 60-100L capacity) and reticulum or honeycomb/net (about 10L capacity) act as fermentation vats in which plant material is broken down by millions of micro-organisms. Food not digested in the rumen passes into the omasum.

Between 60 and 70% of all digestion occurs in the rumen. During this process, fibre and other pasture constituents are broken down and converted to microbial protein. This together with rumen micro-organisms is washed into, and then digested in the abomasum and absorbed in the small intestine to provide protein for the animal. Carbohydrates are fermented to volatile fatty acids (VFAs) and absorbed across the rumen wall where they enter the blood stream and are converted to glucose and fat. The rumen is active in cattle from 2 months of age onwards.

## Rumen Micro-organisms

The rumen contains vast numbers of micro-organisms (bacteria, protozoa and fungi), bacteria being the most numerous. These microflora grow rapidly with up to 10 generations per day. The diversity of rumen bacteria undertake all the necessary processes to break down and digest most plant components producing microbial protein (animal's main source of protein) and VFAs (main source of energy). Protozoa and fungi digest cellulose and plant fibre. Some protozoa can however be predatory to other organisms in the rumen, particularly as numbers multiply rapidly in cattle fed large quantities of grain.



## Omasum

The omasum or bible has a capacity of about 15L, holds and absorbs water, further grinds food particles through muscular contractions and provides passage of food to the abomasum.

## Abomasum

The abomasum or true stomach (capacity about 20L) digests protein and some fats using acids and enzymes. Food then passes through the abomasum to the small intestine.

## Small intestine

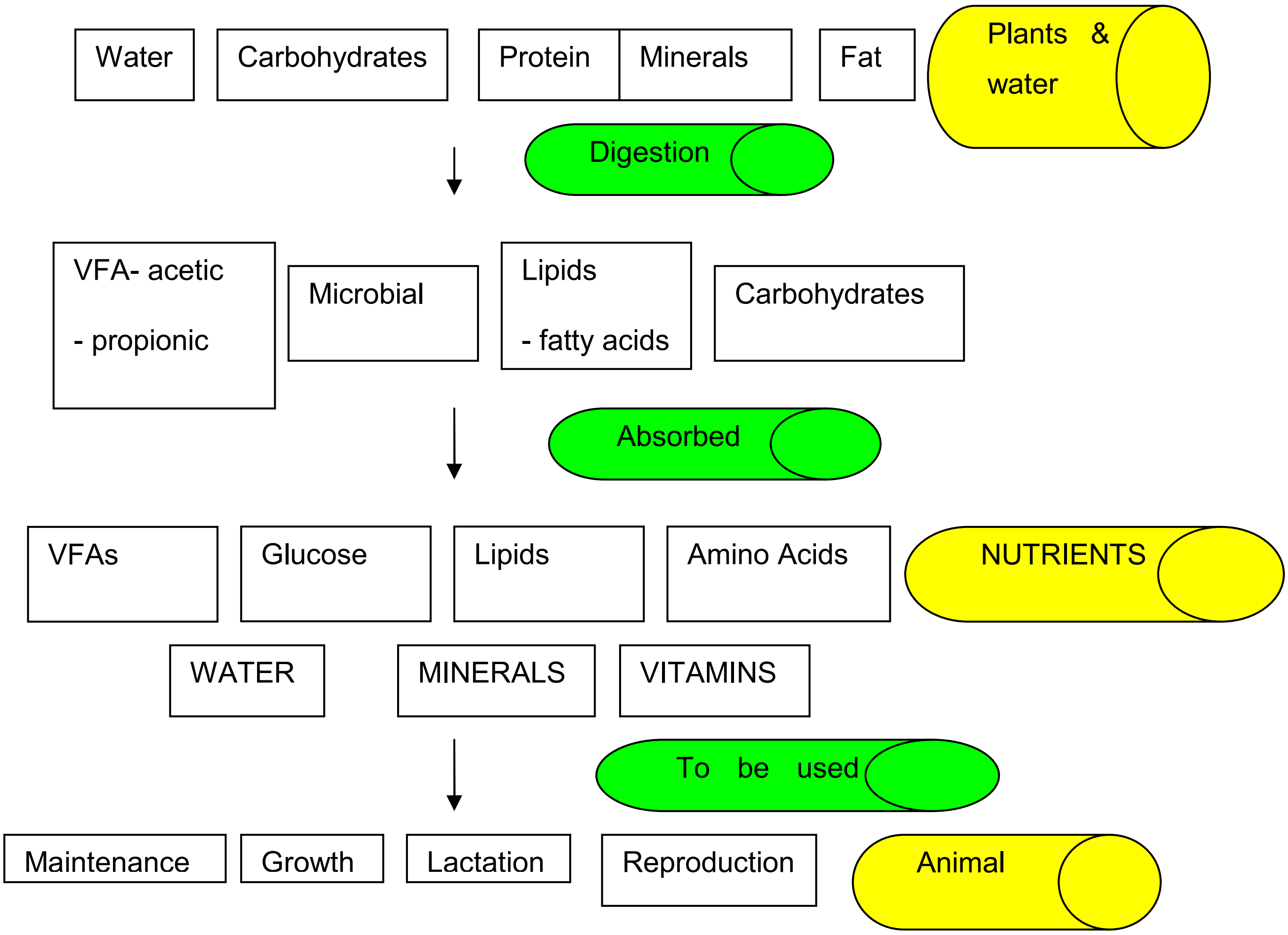
With the help of secretions from the pancreas and bile duct, the small intestine, which is about 30-50 m long, digests and absorbs amino acids, fats and glucose. The remaining material then passes to the large intestine.

## Large intestine

The different sections of the large intestine (caecum, colon, rectum) are about 10m long and absorb water and collect waste material from digestion prior to defecation. There is also some fermentation occurring in the caecum, particularly in cattle on grain-based diets.

## Nutrients

The processes of digestion, absorption and utilisation of nutrients are shown below.




## Water

Water is the most important of all nutrients, accounting for approximately 70% of body mass. It is used for all essential processes, the most important of which are:

- digestion, absorption and transport of nutrients and metabolites around the body.
- removal of waste products of digestion and metabolism.
- thermoregulation, affected by evaporation of water from the respiratory tract and from skin surfaces.
- respiration, and
- regulating mineral balances.

Water also regulates blood osmotic pressure and is a major component of secretions (milk, saliva and other digestive fluids) as well as the products of conception and body growth.

While an animal may lose almost all of its fat and half of its protein during starvation, and still survive, the loss of one-tenth of its body water can be fatal.

Animals gain water in three ways: by drinking, in feed and as ‘metabolic’ water formed during oxidation of nutrients from the diet and from body tissues.

## Energy

Energy is not an actual substance like proteins or minerals. It represents the capacity of various food components to allow the animal to perform its regular functions of movement, metabolism, growth and reproduction. The major food components that contribute to energy are carbohydrates, fats and protein.

The process of energy capture and transfer is very inefficient. Only a small proportion of radiant energy is converted to animal proteins such as meat and wool, and much of the energy is lost as heat during digestion and metabolism, and excreted by animals as dung and urine.

The energy contained in food is measured in terms of Metabolisable Energy (ME), which really represents the useful energy for the animal. After allowing for energy losses through faeces, urine and rumen gases, ME describes the capacity of food to provide the fuel for all the processes an animal will perform. ME is measured in metric units as megajoules per kg dry matter (DM) (MJ/kg DM) of the food being tested. In some American publications, for example National Research Council (NRC, 1980) tables, ME is measured in Kcal/lb and must be converted to relate to metric units. There are 4.184 joules in a calorie, and 2.2 lb in a kg).

The most important factors influencing energy requirements are:

- Liveweight.
- Sex – bulls have higher maintenance requirements than steers or cows.
- Breed – *Bos indicus* breeds have lower maintenance requirements than *Bos taurus* breeds.

- Activity – distance walked to water, e.g. cattle in northern Australia compared to those in feedlots.
- Required weight gain and age of cattle involved – older cattle laying down fat require 2-3 times more energy than younger cattle laying down muscle for the same live weight gain, and
- Physiological status – cows in late pregnancy and early lactation require greater than 50% more energy than empty or early pregnant cows.

Pasture Dry Matter Digestibility (DMD) as supplied through Near Infrared Reflectance Spectroscopy (NIRS) faecal testing and energy content are directly related as illustrated in the following table and in Figure 4.

| DMD % | Energy ME (MJ/kg DM) |
|---|---|
| 80 | 12 |
| 70 | 10 |
| 60 | 8 |
| 50 | 6 |
| 40 | 5 |

Throughout the dry season, most northern Australian pastures have 40 – 60% DMD which theoretically cannot support growth, reproduction or lactation in cattle, without some form of supplementary feeding.

## Protein

Proteins are a significant component of muscle, comprise most of the enzymes that drive metabolism, and are a component of the hormones that regulate body function. Proteins are made up of chains of peptides, which are in turn made from chains of amino acids. Amino acids are relatively small molecules made up of varying configurations of carbon (C), oxygen (O), hydrogen (H), nitrogen (N) and, to a lesser extent, sulphur (S) and phosphorus (P). For protein synthesis to be optimal both S and P are required, and deficiencies of these can influence protein metabolism and utilisation.

The protein percentage of a supplement or feed can be calculate by multiplying the N level by 6.25. For example:

Early dry season tropical grass with 1.2%N = 7.5% CP

Once rumen micro-organisms break down protein they then use the resultant ammonia to build their own bodies, and synthesise microbial crude protein (MCP), the protein incorporated in microbes. When the microbes are washed from the rumen they are digested in the abomasum, and the resultant amino acids are absorbed in the small intestine.

Energy is needed to drive protein production in the rumen, and the ideal ratio of energy (measured as total digestible nutrients (TDN)) to crude protein is about 6-7:1. This ratio can be estimated from NIRS faecal testing (Coates 2001) which provides dry matter digestibility (DMD) and CP %. TDN can be calculated from DMD through the formula: TDN = DMD – 5. If energy is deficient, the now surplus ammonia will be lost in the urine; if protein is deficient the surplus energy will be used inefficiently in other metabolic processes.

There is also an upper limit to the rate of microbial synthesis of protein, and if protein is surplus to this requirement, the excess ammonia will be lost via the urine. This is rarely encountered under grazing conditions in northern Australia but can be seen on high protein forages such as lucerne and rye grass pastures in temperate areas.

Microbial protein makes up approximately 70% of all protein absorbed from the small intestine. The concept of microbial growth using non-protein nitrogen (NPN), for example urea or rumen degradable protein (RDP), is one of the most important in ruminant nutrition.

Protein requirements depend on:

Age – younger animals have higher requirements as they are laying muscle.

- Growth rate.
- Pregnancy – foetal requirements, and
- Lactation status – milk has a high percentage protein

It is generally considered that a diet containing 6% crude protein (CP) is a maintenance level for a non-lactating, non-pregnant 400kg animal. Most pastures in northern Australia when mature, dry and sometimes frosted contain less than 6% CP from June to October.

The amount of crude protein in the diet can be calculated by multiplying the Nitrogen content of the feed by 6.25.

## Intake

Intake is the most important factor influencing the level of nutrients obtained by the animal. Intake is usually referred to in terms of DM intake (i.e. the non-water component of feed), and is often expressed as a percentage of body weight. As can be seen in Figure 6, DM % in tropical grasses can vary from <30% to >80% depending on species, season and stage of growth. Hay ranges from 80-90% DM, grains about 90% DM, silage about 50% DM, molasses about 70% DM, and commercially available liquid supplement products are about 50% DM.

All comparisons of nutritive value and costs of supplements should be done on a DM basis as this indicates the amount of useful nutrient absorbed by the animal, and therefore the true value of the supplement. Dry matter is particularly important when comparing the energy and protein value of roughage such as hay and silage. For example the DM% of silage is approximately 35% and that of hay is approximately 87%. Chemical analysis on a dry matter basis shows that corn silage has 10 and 20% more energy than Lucerne and barley hay respectively. However, if they were compared on an 'as fed' basis it would be wrongly assumed that hay had more energy than silage.

A number of factors influence dry matter intake (DMI):

- Digestibility and rate of passage through the rumen is most important. DMI of dry winter feed is approximately 1.5% of bodyweight (BW) compared to feedlot rations at 3% of BW.
- Pasture yield and sward height.
- Stage of growth (see Figure 6).
- Palatability.
- Contamination effects (faeces and plant diseases).
- Nutrient balance.
- Stressors in the animal (parasites, heat, cold and disease).
- Age and class of animal.
- Lactation status, and
- Water quality.

Unfortunately, some high producing animals (eg lactating cows, young growing animals) cannot consume the volume of poor quality feed needed to satisfy demands. This may even occur in cattle on these pastures supplemented with NPN. In these situations, high producing animals will need to be supplemented with energy dense feedstuffs that contain under graded protein (UDP) or bypass protein as well as NPN.

It is important to remember that urea improves performance by improving the protein status of an animal. This results in an increased intake of pasture by up to 30%. What this really means is **an increase in effective grazing pressure (stocking rates).**

Though this may not be a universal problem, it has often not been sufficiently well recognised, particularly in some less fertile and lower rainfall areas of central and northern Australia, leading to over-grazing and pasture deterioration problems, with reduced cattle performance.

## Minerals and vitamins

In most situations, grazing animals can generally satisfy their requirements for minerals and vitamins from pasture. However, in some parts of northern Australia with low soil P levels, P deficiencies can occur. Responses to phosphorus supplementation alone can be evident during the 'wet' season in northern Australia when the levels of both energy and protein are adequate in the diet. Deficiencies of other minerals are generally confined to isolated areas.

Vitamin deficiencies generally only occur in extreme conditions such as severe drought, or in feedlot rations not supplemented with vitamins. Rumen micro-organisms have the ability to synthesise most vitamins, the exceptions being vitamins A and E that are readily available in high quality forage, and vitamin D that is synthesised by exposure to sunlight. In some cases vitamin deficiencies are induced by deficiencies in specific minerals, eg a deficiency of cobalt (Co) induces a deficiency of vitamin B12.

Both excess and insufficient amounts of minerals can cause problems, either through toxicity or because of secondary effects. As an example, too much S or molybdenum (Mo) can induce copper (Cu) deficiency.

Minerals are generally divided into macro- and micro (trace) minerals, based on animal requirements. Macro minerals in order of importance in Australia include phosphorus (P), sulphur (S), calcium (Ca), sodium (Na), potassium (K), and magnesium (Mg). Trace minerals (trace elements) include Cu, Co, selenium (Se), zinc (Zn), iron (Fe), iodine (I) and manganese (Mn).

More detailed information on animal mineral requirements and mineral contents of feeds can be found in the Nutrition EDGE Network Workshop notes and are summarised in Table 1 below.

It should also be recognised that ratios of minerals are as important as absolute requirement. For example the Ca :P ratio should be 1.2 to 2:1 and the N:S ratio should be about 10 to 15:1, since S is a vital component of the ruminant diet and is essential for microbial digestion of NPN and other protein sources. Calcium is rarely deficient in grazing animals and is often in high concentrations in poor quality waters.

Tropical grasses tend to have :

- Marginal to low Na levels.
- High K levels (in early vegetative stages).
- Imbalance in Ca:P ratio, and
- High Mg in some grass species.

Table 1. Estimated requirements by cattle for some macro minerals (Ref: Feeding Standards for Livestock. Ruminants 1994). (Note requirements will vary depending on intake, age, liveweight, physiological status).

| Mineral | Dietary requirement (g/kg DM) |
|---|---|
| Phosphorus | 1.8-3.2 |
| Sulphur | 1.5 |
| Calcium | 1.9-4.0 |
| Sodium | 0.8-1.2 |

In northern Australia, the most important mineral deficiencies are P and S.

## Phosphorus

Phosphorus is the second most plentiful mineral in the body after Ca, and is present in all cells of the body, although most is in the skeleton. The most important roles of P are the conversion of feed into energy, build-up and repair of body tissues including bone, in the developing foetus and in production of milk.

Due to the requirement of P for growth, reproduction and milk production, common symptoms include poor growth and fertility. In deficiency situations, cattle mobilize phosphorus from their skeleton leading to soft and weak bones and, in extreme cases 'peg leg'. Phosphorus and Na, are the two minerals that cattle can recognize as being deficient in their diets, and they will seek alternative sources. In the case of P deficiencies, this leads to bone chewing, and the possibility of botulism in unvaccinated cattle.

About 70% of northern Australian soils have some degree of P deficiency. A number of factors influence the level of P available to the animal including:

Soil type and pH. Large scale maps indicating likely regions of P deficiency have been published for northern Australia (McCosker and Winks 1994).

Pasture growth stage. Concentrations of P in mature dry season pasture may be 25% of those in actively growing early wet season pastures (Figure 6).

Lactational stress. Milk production increases the demand for phosphorus and "peg-leg" is usually seen first in cows suckling a calf, and

Protein and energy intakes. High energy and protein intakes during the wet season enable rapid growth and milk production, and the need for P also increases markedly. Thus, although pasture P concentration is much higher during the wet season, P deficiency is also most evident and supplementation is required. However in many uncontrolled mated herds in very deficient areas, a proportion of cows will be lactating during the dry season and will benefit from P supplements.

There can be marked seasonal variations in concentrations of both P and N in many northern pastures, and a typical example is shown in Figure 6.

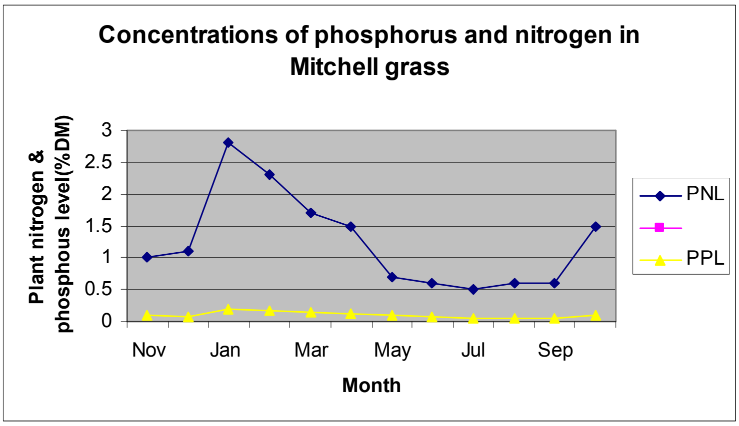



Figure 6

Research has shown that Gross Margins were increased by 57% when acutely deficient herds were supplemented with P, and by 7% in herds with marginal deficiencies (McCosker and Winks 1994).

In the past, some fertilizer grade phosphorus supplements have had high concentrations of contaminants and cumulative toxins such as cadmium and fluorine that accumulate in body tissues over time. More recently, Australian Standards for fertilisers in relation to contamination with cadmium, lead and fluorine, have minimised these problems

In the early days of water medication, commercial grade black phosphoric acid was occasionally used as a P source, and caused depressed water and feed intakes and lost production. Similarly when phosphoric and other acids have been used to de-scale pipelines, care should be taken to flush lines to avoid depressed water intakes and potential toxicity problems.

## Sulphur

Sulphur is needed as a nutrient by rumen micro-organisms to digest fibre and starch components in the diet. The ratio of N to S is important for efficient function in the rumen, a ratio of 10:1 being accepted as optimal, though this can range from 5:1 to 20:1.

Sulphur sources are discussed in more detail in Section 6 (supplements), but the most common are sulphate of ammonia (SOA-GranAm) and elemental sulphur, though the latter is not soluble.

## Role of supplements in managing nutritional deficiencies

*Diagnosis of nutritional deficiencies:* If cattle are showing signs of ill thrift or disease, help should be sought from local veterinarians or Departmental field officers for confirmation of the cause. There are many reasons why grazing animals may not perform as expected. One of these reasons is poor nutrition.

Others are:

- Production potential of the country.
- Seasonal conditions.
- Genetics.
- Diseases including parasites.
- Grazing management strategies.
- Animal management strategies.

It is important to consider all these possible causes before assuming that nutrition is the cause of the problem, and before starting to supplementary feed. It is also important to consider the economics of a supplementary feeding program, since it may be more economical to accept a lower level of performance. Consult other producers in the district and eliminate reasons other than nutrition that may be the cause of lower than expected production levels. As an example, experimental evidence in north Queensland has shown that the benefits of earlier weaning on breeder live weight were about twice the benefits obtained by using urea-based supplements for breeders (Dixon 1998). If nutritional deficiencies appear to be the cause, think about energy and protein first. If these are adequate, then consider the macro-minerals that are most likely to be deficient in northern Australia.

Objective measurements that can be used in diagnosing nutritional deficiencies include:

- NIRS and other faecal analysis.
- Faecal consistency.
- Pasture analysis.
- Historical records of rainfall and frosts.
- Pasture budgeting – kg DM / ha.
- Soil analysis.
- Animal samples – blood, liver, hair (should generally be carried out under veterinary or departmental supervision).
- Body condition score/ weight changes, and
- Production responses and patterns

The role of supplements is important in preventing or minimising nutritional deficiencies. A more detailed discussion on types and levels of supplements is presented in Section 6.

## Supplementation techniques and options

The real challenge in supplementary feeding in extensive grazing situations is achieving target intakes. Work with both cattle and sheep indicates that the proportion of shy feeders (consuming <25% of target intakes) can be very high (>50%).

It is well known that the variability of intake and the percentage of non-consumers are low for high-palatability supplements such as cottonseed meal (CSM), grain-based concentrates or molasses based supplements. However, variable intake is a much greater problem for less palatable supplements such as dry lick or block supplements, where in some situations the percentage of non-consumers is high.

Voluntary intake of dry lick supplements is generally increased by the inclusion of palatable components such as CSM, molasses or, in some cases, salt in the mixture. In some experiments the inclusion of CSM as 30% of a dry lick increased voluntary intake by between 30 and 90%.

Cows being supplemented Di Calcium Phosphate (DCP)

Conversely, where excessive intake is a problem, supplements can be made less palatable by the addition of ingredients such as SOA (Gran Am), excess salt or addition of acids in proprietary molasses based supplements. High phosphorus content blocks are also less palatable than those with a more moderate phosphorus content.

During the wet season, due to high pasture palatability and the large increase in available water, insufficient intake of mineral supplements such as P is a common problem. More palatable supplements are needed when wet season pasture is available than under mature dry season pasture conditions.

Other wet season problems include protection of the supplement and equipment from seasonal conditions, and access to delivery sites. Medication of nutrients through the water is also variable especially if there are large numbers of surface waters in the paddock. During the dry season, problems and inefficiencies may be associated with either excessive or inadequate intakes of supplements.

Training and familiarisation of younger cattle to supplements and feeders and to some specific flavours may have a role in increasing early acceptance of supplements by cattle when they are fed at a later stage of their life.

Water medication is an alternative strategy for supplying NPN and other supplements such as P. The advantages and disadvantages of this technology are discussed in more detail in Section 5 of the manual.

## Non-protein nitrogen (NPN) supplementation

Non-protein nitrogen sources are those sources of N not derived from a protein supplement such as copra-meal or cottonseed meal. **Urea** is the most common NPN supplement used. This is because it is:

- Relatively cheap and extremely effective.
- Readily available.
- Rumen microbes produce the enzyme urease that breaks urea down to ammonia, the building block for MCP.
- relatively palatable when compared to other NPN sources, and
- Dissolves in water (this can be a disadvantage if dry lick is the vehicle of choice).

The obvious disadvantage of urea is that it is **very toxic at high levels.**

When to start feeding urea Supplementing cattle with urea or other NPN sources generally does not improve production. The objective of using NPN is to prevent further loss of production, hence it is important to start supplementing before cattle start losing bodyweight and condition.

There are various methods of determining the timing of the start of urea supplementation. Objective measurements though they may be expensive and time consuming, are generally more accurate and repeatable. These include NIRS faecal sampling, rainfall and frost records and historical and current production records. Faecal samples containing < 6% CP levels, falling CP and digestibility levels of pastures; occurrence of the first frost; month since the last significant rainfall; and levelling out or falling of production measurements indicate feeding urea or protein supplements is needed.

The usual and most effective subjective assessment is observing the consistency of faecal pats. When the faecal pat begins to mound, dries out quickly to a hard fully formed pat and becomes readily visible in the paddock, producers should commence urea feeding. Some examples of differences in pat consistency are shown in the following photographs.

Other methods of subjective assessment include physical appearance of cattle such as 'lack of fill' (observed as a hollow area at the flank) and appearance of the pastures.

## Recommended amounts of urea to be fed

Most current recommendations on urea levels are based on work in north Queensland by Lyle Winks and colleagues in the 1960s and 70s. The conclusions from that work were to feed urea at about 30g/d for 200kg weaners and 60g/d for lactating cows. Beyond these levels, energy becomes limiting, and increasing urea levels may not increase responses.

These general levels have been adopted when providing urea through water medication. There is now some work in progress on the Barkly Tableland aimed at establishing the best levels of urea supplementation for cattle on water medicators.

## *Urea toxicity: cause, signs, diagnosis, treatment and prevention*

There have been numerous reports of toxicity problems with urea being fed, not only through water medicators, but also in dry licks and blocks. At the suggestion of numerous producers, a short section on urea toxicity is included here.

***Cause:*** The toxic effects of urea are due to the ingestion of a large amount of urea, causing sudden production of large quantities of ammonia in the rumen. This excess cannot be utilised by rumen micro-organisms, resulting in absorption of large amounts of ammonia across the rumen wall into the blood stream. Urea toxicity occurs when the amount of ammonia in the blood is more than can be handled by the liver.

The severity of signs is related to blood ammonia levels that affect other organs particularly the brain. Clinical signs and death within 20-30 minutes of ingesting urea can be caused by respiratory failure due to ammonia intoxication; gaseous bloat caused by rapid build up of ammonia gas in the rumen, and neurological intoxication with ammonia.

Toxic dose levels of urea vary, but in cattle which are hungry or dehydrated, levels up to 0.33 g/kg BW cause increases in blood ammonia levels; levels of 0.44 g/kg BW produce signs of poisoning within 10 minutes of dosing and levels of 1 to 1.5g/kg BW cause rapid death. The common daily urea dose for a breeding cow in northern Australia is 60g which equates to a dose of 0.13g/kg BW.

Animals unaccustomed to urea may show clinical signs when fed high levels, but gradual and incremental increases in urea intakes can be tolerated. This tolerance is lost rapidly and animals that receive no urea for three days are again susceptible. Tolerance is also reduced by starvation and by a low protein diet. This emphasises the need to ensure all stock are well fed and have water available before gaining access to urea based supplements.

***Other Species:*** All ruminants including sheep, cattle, camels, goats and pseudo-ruminants such as marsupials, are highly susceptible to urea toxicity. There is no urease (enzyme which metabolises urea) in the gut of monogastrics such as horses and dogs, and they are tolerant to relatively large amounts of urea, up to about 1.5g/kg, beyond which toxicity can occur. This equates to 600g in an average stockhorse. The clinical picture in horses and dogs is similar to cattle.

***Clinical signs:*** There are no specific symptoms of urea toxicity. Cattle usually exhibit a range of signs and some or all of the following may be seen:

- Excessive salivation.
- Severe abdominal (gut) pain, sometimes with teeth grinding.
- Muscle and skin tremors and spasms.
- Uncoordinated, proppy gait with staggering.
- Weakness.
- Breathing difficulties, usually slow, deep and laboured.
- Collapse and bloating.
- Violent struggling and bellowing.
- Frothing at the mouth.
- Regurgitation of rumen contents, and
- Tetanic spasms immediately before death

The course of symptoms is short, and the death rate in affected animals is high. There are no characteristic post-mortem lesions, but most cases show generalised clogged blood vessels and bleeding, resulting in dark carcasses and internal organs, and fluid swelling (oedema) in the lungs. There is often bloating of the carcass, with a large amount of frothy ruminal fluid at the mouth and nostrils. Rumen alkalinity and high rumen (smell) and blood ammonia levels are also obvious signs. Urea supplement history, signs of bloat and large amounts of ruminal fluid seen at the nostrils after death are usually good indicators of urea toxicity.

***Diagnosis:*** of urea toxicity is easy when deaths occur in numbers of animals, but where there are deaths of single animals, it is sometimes difficult to distinguish these from some cases of plant poisoning. However deaths due to urea poisoning are usually rapid, and often occur close to the trough or urea source.

***Treatment:*** The only really effective treatment is prompt and efficient emptying of the rumen via a large bore tube (trocar) punched into the rumen high on the left flank, though this is not always practical.

No other treatment is likely to be effective, although in early cases, the oral administration of 4L of a weak acid such as vinegar or 5% acetic acid may increase rumen acidity, reduce the amount of ammonia produced and absorbed and, therefore act as an antidote. Repeated treatment may be necessary, as clinical signs tend to reoccur about 30 minutes after treatment. Symptomatic treatment may also be effective. For example, bloat can be treated by inserting a trocar into the rumen or in some cases by passing a stomach tube into the rumen through the mouth.

A first aid kit for urea poisoning should include vinegar or 20 litres of acetic acid, disposable trocars, a stomach tube and a mouth gag for administering acetic acid.

***Prevention is better than cure:*** Urea toxicity is best controlled through astute management of supplement programs. There are effective recommended guidelines for prevention of urea toxicity, which apply no matter how the urea is fed.

These include:

- Never provide urea to thirsty or hungry cattle.
- Commence feeding earlier in the season rather than later to avoid access by hungry cattle.
- Ensure cattle coming out of the yards or off trucks drink at a urea free trough until their thirst is quenched and they are allowed to graze for 48 hours before being exposed to urea based supplements.
- Ensure urea is available to cattle (depending on the method of supplementing) consistently during the supplement season. Erratic feeding may result in gorging and deaths.
- Try to maintain urea intakes at the recommended levels of 30 to 60g/head/day, irrespective of the supplement method used. When feeding urea in a combination of water medication and dry lick, ensure these levels are not exceeded.
- Staff training in the risks of urea toxicity, mixing of supplements, and monitoring of intakes, equipment and the health and welfare of cattle is extremely important. Often mortalities from excessive urea intake are caused by human error.

Where urea is being fed through **water medicators:**

- Feeding levels should commence gradually, starting at about 20g/day for 10 days, increasing to 40g/day for the next 10 days, and finally to desired levels.
- Complete and frequent mixing of product in the concentrate tank is a '**must do'**. Either mechanical or physical mixing is suitable and a mesh scoop to check for any undissolved product is a useful tool.
- Never place either concentrated or dilute urea supplements in open storage tanks, as evaporation will increase urea concentration. It is preferable for the concentrate tank and medicator to be placed between the storage tank and the troughs.
- Urea should never be fed at >2g/L water. Concentrations above this level will depress water intakes and increase intakes of urea to risk levels.
- Monitor water intakes and adjust dose rates accordingly.
- Ensure there are no other sources of water available to supplemented cattle.
- Concentrate tanks should be cleaned and equipment flushed with clean water at the end of a feeding period.
- Concentrate tanks should only contain sufficient supplement to supply cattle for 7 to 10 days. This ensures good turn over in the tank, and detrimental impacts of poor quality water are minimised, and
- Regular maintenance of equipment and replacement as necessary is essential in preventing malfunctions. Tampering with medicators, water meters or connections should not be considered until the supplier is contacted.

# SECTION 3. WATER INTAKE BY GRAZING CATTLE

All animals have to consume water to fulfil essential bodily functions such as digestion, growth, milk production and reproduction. If water intake of animals is restricted then dry matter intake also falls, one or more of these essential functions will be affected, and performance and production levels will suffer.

Gross productivity trials have concluded that the frequency with which cattle drink water appears to be less important than the amount they can drink at a given time. However, when feeding urea either through feed or water, responses are significantly improved if animals eat or drink little and often. More frequent exposure to urea increases the percentage of urea metabolised by the rumen microbes and, therefore, increases supplement efficiency, pasture intake and improves productivity. This may explain why in areas with smaller paddock sizes, shorter distances to water and better pasture digestibility there is a productive weight gain over winter, rather than a weight maintenance response to urea.

Cows watering on trough

## Factors influencing water intake

Cattle of different sizes, breeds and reproductive status (e.g. wet *v* dry cows) have different water requirements, and thus planning for water facilities and for water medication strategies needs to take these factors into consideration.

Seasonal and environmental conditions will also affect water needs. Animals on good quality wet season pastures with a high water content have somewhat lower water consumption patterns than animals on poorer quality dry-season pastures, due not only to higher water content in wet season grasses, but also to differences in water requirements for digestion of high quality compared to low quality pastures.

As environmental temperatures increases, animals require more water to maintain body temperature at a stable level. Distances between water points can also influence frequency of drinking and amount of water consumed, which can be important when water is being medicated with urea.

Animal factors such as weight, reproductive status (pregnancy, lactation), stress, other animal behaviour characteristics and genotype can also influence water intake, and there can be large variations between similar individuals.

In order to effectively use water medication, nutrient concentrations must be adjusted so that animals get the required intake of a specific nutrient every day. To do so requires knowledge of water intakes and an appreciation of some of the factors that influence water intake.

Daily water intakes can be calculated for most water medicators, provided the number of animals on that water point is known. This is done by measuring water flow into the trough from either an electronic or mechanical water meter, and logging of water intake data (see Section 5). However in other situations where a water grid system is used, and supply to a trough may come from several interconnected bores, water intakes cannot be accurately measured and will have to be estimated.

A widely used value for calculating water needs and size of water facilities for beef cattle has been an average daily water intake of about 10% of live weight. Thus for a 450kg steer, a daily intake of 45L (10 gal) is a reasonable rule of thumb. From other work we know that each day, cattle drink about 4L/kg grass DM eaten. As grass DM consumption is about 1-3% of live weight, a theoretical daily water intake is approximately 44-50L for a 450kg steer. This is very similar to the rule of thumb estimate above.

While it is all very well to give some average figures and estimates, the variation and range in water intake is more difficult to predict. Unfortunately there is not a lot of objective data on water consumption of cattle in different regions and under different conditions throughout Australia, and this makes it difficult to give firm suggestions and recommendations on average intakes.

Water quality also has a significant effect on daily water intake. On more than one property in central Queensland where breeders were consuming poor quality water, daily intakes during winter months dropped to as low as 9 to 12L/head, but improved to about 25L/head when water quality was modified and improved. These low water intakes would probably have had a significant effect on feed intake and hence on production.

A few other factors that can influence calculations of water intake include the impact of stock that have not been accounted for (not mustered), and water consumption by feral animals (goats, brumbies, donkeys, camels) and native wildlife using these water sources. In some situations these impacts could be considerable and water intakes of domestic livestock may in fact be lower than calculated from total water consumed at a particular water point.

## Water intake levels

The limited amount of information suggests that daily water intakes can vary up or down by up to 20% depending on the effects of the factors mentioned. A good rule of thumb therefore is to over-estimate water intakes, rather than under-estimate, particularly during hot weather and for cows with calves at foot.

The absence of data is mostly due to the fact that many producers do not make these calculations, although most who are using water medication do record total water passing through a water meter in a given time period. This information is generally recorded in a notebook or equivalent at the site of the nutrient dispenser. Numbers of cattle, (converted to Livestock Units (LSU), Adult Equivalents (AE) or Dry Sheep Equivalents (DSE)) present in each paddock or cell are generally kept in records in the office. Unfortunately in many circumstances these two sets of data are not combined to calculate daily intakes.

In the case of clients of Resource Consulting Services Pty Ltd (RCS), LSU numbers are recorded on the Graze Charts under the manager's care, and can then be combined with water data to calculate litres consumed / LSU / day. This is easily done in a computer driven spreadsheet program, or manually with a calculator.

One producer in central Queensland actually carries a laptop computer with him while servicing water medicators, and inputs data on water consumed and livestock numbers at a medicator to give an immediate and permanent record of daily water intakes. While this is not to suggest that a computer is needed for these tasks, this approach provides immediate access to previous data on which to make decisions for changes in supplement rates.

The following table compiles some water intake data for cattle from information published in Australia and overseas, as well as from records of a number of producers.

Table 2. Information on water intake by location, breed, type and size of animal and season.

| Location | Breed | Animal Type | Weight Range (kg) | Water Intake (L/d) | Source |
|---|---|---|---|---|---|
| Coastal North Qld | Brahman cross | Weaners | 170 to 190 | 10 to 13 | McLennan et al 1991 |
| Pastoral West Australia | Not specified | Steers | 400 | 9 to 53 | Luke 1987 |
| Western Victoria | Angus<br><br>(Drought fed) | Yearling steers | 300 | 20 to 25 | Birrell 1992 |
| NW Qld/Gulf | Brahman | Breeders | Av 400 | 20 to 70 | T Mott, A Lord, S Thomas, D Makim,<br><br>G Forster (pers comms) |
| Central Qld | Brahman cross | Breeders<br><br>Steers | | Up to 100 (heat wave)<br><br>20 to 60 | J Mctaggart(pers comm.)<br><br>A McTaggart, D Miller, R Sparke, G Robertson (pers comms) |
| Central Western Qld | Brahman cross<br><br>Droughtmaster | Breeders<br><br>Various | 400 | 37 to 40 (summer)<br><br>15 (winter)<br><br>28 to 35 (winter)<br><br>87 (summer)<br><br>45-60 | M McKellar (pers comm)<br><br>R Mackenzie (pers comm)<br><br>W Ferguson (pers comm.) |
| Alice Springs | Brahman | Various | | 35 to 55 | C Nott (pers comm) |

Table 2 (cont.) Information on water intake by location, breed, type and size of animal and season.

| Location | Breed | Animal Type | Weight Range (kg) | Water Intake (L/d) | Source |
|---|---|---|---|---|---|
| Australia (compiled data, several sources) | Not specified | Lactating cows | | 66 (25$^0$C)<br>72 (32$^0$C) | McCosker 2000 |
| Arcadia Valley | Santa x Angus | Breeders | 450 | 25(winter)<br>35(spring) | R McKinlay (pers comm.) |
| Coastal Qld | Brahman | Breeders | 400 | 6 to 9<br>25 after magnets installed | S Waterson (pers comm) |
| | Brahman | Yearling heifers | 250 | 10 to 12 (winter)<br>20 to 22 (summer) | R Thieme (pers comm) |
| | Brahman cross | Breeders | 400 | 15 (winter)<br>60(summer) | G Ashford (pers comm.) |
| Southern Qld | Bos taurus cross | Breeders | 500 | 10 to 12 (winter)<br>25 (summer) | B Schraggs (pers comm) |
| | | Steers | 300 to 400 | 35 to 36 summer<br>27 to 28 (bad dam water) | P Erbacher (pers comm.) |
| USA | Not specified | Growing cattle | 360 | 38 (25$^0$C)<br>57 (32$^0$C) | Winchester and Morris 1956 |

In summary, this data and the experience of many producers suggests that average intakes on reasonable quality water range around 45-55L/day for mature animals weighing about 450 kg. However these estimates should be increased by at least 25% for cows with calves at foot, and for periods when high temperatures occur. Overestimate rather than underestimate water requirements.

# SECTION 4.  ASSESSING WATER QUALITY

## Importance of assessment of water quality

With or without medication, water quality obviously influences water intake which in turn influences animal production. Most producers with experience in water medication emphasise the importance of assessing water quality **before** using water medicators, since water quality issues may influence the success or otherwise of this technology.

There is also considerable anecdotal evidence of adverse interactions between minerals that may be in the water and those that are added via the medicator. These effects can have significant impacts on both water intake, and on the efficiency of water medication operations.

Stock water sources can be divided into a number of categories :

- **Surface water** such as streams and dams where quality can be influenced by catchment geology, topography, soil type and climate. Particular problems with surface water relate to increased biota (algae and bacteria) when additional nutrients such as nitrogen, sulphur and phosphorus are evident, e.g. fertiliser run-off from agricultural areas.

- **Shallow** ground water (<80m) that can be easily contaminated with nitrites and nitrates from fertilisers and animal effluent

- **Sub-artesian** ground water (100-300m)

- **Artesian** ground water high in ‘chlorides’ that is often also high in sulphur derivatives and can be very difficult to treat.

- **Artesian** ground water high in ‘bicarbonates’. Oxidising these waters may reduce the bicarbonates and improve the water quality.

All types of groundwater, which are widely used as a source of drinking water for livestock, can vary greatly in quality. These waters may contain large quantities of dissolved salts, depending on the soil and parent rock of the surrounding area and other factors including rainfall, evaporation, vegetation, topography and catchment land use practices.

## Water analyses

Water samples should initially be analysed at an appropriate laboratory to establish base line levels of a range. It is also important to regularly monitor water quality on site, particularly pH that can be determined relatively easily. Water analysis should be cost effective, only covering those tests that will have a significant effect on water quality. Don't test for unusual or exotic toxic elements unlikely to be present.

There are several laboratories and companies that provide routine water analytical services including:

Agritech Laboratories
Diana Abbott (Manager) and Robert Lascelles (Chief Chemist and Assistant Manager)
214 McDougall St
Toowoomba Q 4350
Ph 07 46330599 Fax 07 46330711
Website www.casco.com.au

Agritech provide a stock water profile and are NATA accredited for water analysis. They provide opinions on suitability for stock and if requested will also provide algae and bacterial counts. (June 2004 costs, $110)

Gundrill Trading Pty Ltd
Ian Gundrill
PO Box 534
Arundel Q 4212
Ph 1300 888 008 or 07 55633335
Email gundrill@bigpond.net.au

Water samples are sent to laboratories for analysis and interpretation and advice is provided to producers on solutions to problems. (June 2004 costs, $140)

Previous water analyses services available from Queensland Government analytical laboratories through the Department of Natural Resources (DNR) are no longer available for public testing, though DNR submits samples as they require.

## Local Authorities

Sampling for chemical or bacteriological analysis can be arranged through many Local Authority Health Departments, some of which maintain testing facilities, though this service is generally limited to water for domestic purposes.

**Inclusion of laboratories in the above list does not imply any approval or warranties by MLA of the services offered.**

Typical stock water analyses undertaken by laboratories include the information shown in Table 3.

It is important to note that the acceptable range can vary depending on feed intake of the ion in question or concentrations and interactions with other ions in the water. These **ranges refer to cattle health** and **do not refer to** optimal water intake levels or interactions of ions with substances added to water, for example through water medication.

*Table 3. Typical information included in most water analyses reports, units of measurement and range of acceptable values for cattle health.*

| **Test** | Units of measurement | **Acceptable range for cattle health** |
|---|---|---|
| *Ph* | pH units | 6-8 |
| *Electrical Conductivity (EC)* | dS/cm | <15 |
| *Total Dissolved Solids (TDS)* | mg/L | <10,000 |
| *Total Alkalinity* | mg/L | n/a |
| *Bicarbonate Alkalinity* | mg/L $CaCO_3$ | 60-200 ideal. Above or below this will affect water quality but not stock health. |
| *Dissolved Oxygen* | mg/L | 8 equilibrium value for fresh, properly aerated water, depending on temperature. |
| *Nitrate* | mg/L | <400 |
| *Nitrite* | mg/L | <30 |
| *Sulphate* | mg/L | <1000 |
| *Magnesium* | mg/L | <400 |
| *Fluoride* | mg/L | < 2 |
| *Calcium* | mg/L | <1000 |
| *Chloride* | mg/L | <250 (human consumption) based on taste not health. |
| *Aluminium* | mg/L | <5 May be higher depending on P levels in diet |
| *Zinc* | mg/L | <20 |
| *Copper* | mg/L | <1 |
| *Boron* | mg/L | <5 |
| *Molybdenum* | mg/L | <0.15 |
| *Algal Concentration* | cells/ml and/or µg/L | Microcystis <11500 cells/ml<br><br>Microcystins <2.3µg/L |
| *Bacterial levels* | Thermotolerant coliforms/100ml | <100 |

## Water Sampling

The accuracy of a water analysis is very dependent on the sampling methods employed and the time elapsed between sampling and analysis. Having an analysis carried out is not as simple as filling a bottle and giving it to an analyst. Recommendations provided by the laboratory should be followed in collecting and forwarding samples for analyses.

Ideally, polythene or glass bottles of about one litre should be sourced from the laboratory, DNR or equivalent departmental offices or chemists. Plastic soft drink bottles may be acceptable if they are thoroughly washed out with the water to be sampled. All bottles should be cleaned prior to sampling by rinsing the bottle three times in the water to be sampled, the bottle filled to the top to exclude air and then sealed tightly. Samples should be properly labelled with details of the source, date of sampling, name and address and the intended use of the water.

For flowing water, the sample should be collected from mid stream and mid depth to ensure that the sample is representative of the entire flow in a stream or channel. A note should be made of the condition of flow in the stream (volume and/or velocity of flow) as this often influences the quality of water at different times of the year.

For still waters such as dams and lakes, samples should be taken away from the water's edge and at a depth that represents normal pumping depth. Stratification or layering of the body of water due to seasonal temperature differences and chemical content can result in greatly varying results.

When sampling water from bores and wells, it is important to pump out the 'stale' water inside the casing. Take note of the pumping rate, the water level and the time of sampling after pumping started. Some bores may also have more than one water-bearing zone. It is also useful to sample trough water as water quality can change significantly between the bore and the trough, particularly with very long pipe lines likely to become heated during the summer.

Samples for **bacteriological** analysis should be collected in a sterile container supplied by the analyst. A minimum volume of 200ml is required. The sample should be placed in cold storage (but not frozen) immediately. These samples should ideally be analysed within 6 hours, but certainly no longer than 24 hours after collection. A sample taken for **algae identification** and cell count should be in an opaque bottle of one litre capacity. The bottle should be sealed with about 25mm air space at the top. The sample should not contain thick 'scum' algae as this makes the count inaccurate. If the sample can be delivered to a laboratory within 24 hours, it need only be kept in the dark and in cool storage (e.g. in an esky). Otherwise it must be kept under refrigeration, or on ice, but not frozen.

## Water Quality Measurements

If possible take **electrical conductivity (EC) and pH** measurements at the time of sampling. The recommended combination meter (Patricia Bock, Waterwatch Coordinator, Fitzroy Basin Association, NRM&E, Emerald, (07) 49822956) that measures pH, EC and TDS is a Hannah H198129 (http://www.hannainst.com/) priced at approximately $204. Meters that measure EC only can be purchased for $90-$115; portable pH meters can be purchased for $80-$100.

## pH

pH is a measure of the acid or alkaline nature of a solution. pH 7 is neutral, pH>7 is alkaline, and pH<7 is acid. pH is a vital measure of water quality as it can affect water intake and it also can cause undesirable reactions with other ions in the water and with additives such as urea and phosphorus supplements.

Measurements of pH must be used in conjunction with a full water analysis and an understanding of the buffering capacity of the water. Waters with a pH<6.5 may be corrosive and those with pH >8.5 may cause taste and scale problems (NHMRC & ARMCANZ, 1996).

Contrary to popular belief, the pH of water will not affect pH in the rumen of cattle drinking such water as this is maintained at about pH 6 to 7 by buffers in saliva.

Total Alkalinity (Buffering capacity) reflects the concentrations of carbonate, bicarbonate and hydroxide buffers that contribute to the water's total hardness and its capacity to neutralise acid. Total alkalinity is not to be confused with the alkaline pH measurement of water. When acid is added to water with high pH and high buffering capacity the pH may not change as the buffers absorb the excess $H^+$ ions. Water of this type is said to have a 'high alkalinity'. Water with a pH of 7.5 and a high 'alkalinity' will require three times more acid to neutralise than water with a pH of 8 and a low 'alkalinity' (Wood 2003). Alkalinity problems and urea hydrolysis (breakdown of urea) causing formation of ammonia can be exacerbated by the length of the water pipe line, high temperatures in the pipe line and uneven laying of pipes resulting in gas pockets.

Hard water is caused by high levels of calcium and magnesium carbonates and sulphates. High levels increase the chance of scaling problems in pipes. Hard water is difficult to lather. The hardness can be categorised into permanent and temporary hardness. Temporary hardness is so called because boiling or heating breaks down the carbonate causing the Ca and Mg to precipitate, while the sulphate salts typical of permanent hardness are stable under these conditions (R Lascelles pers comm.) Both hardness and alkalinity are expressed as mg/L $CaCO_3$.

| | |
|---|---|
| <60mg/L $CaCO_3$ | soft but possibly corrosive |
| 60-200mg/L $CaCO_3$ | good quality water |
| 200-500mg/L $CaCO_3$ | increasing scaling problems |
| >500mg/L $CaCO_3$ | severe scaling |

Both high Ca and Mg carbonate and sulphate levels can cause interactions with P supplements which may result in formation of calcium and magnesium ammonium phosphates, both of which are insoluble, can precipitate out of solution, flocculate in water or can form a hard scale in pipelines and fittings. Where waters are acidic rather than alkaline, these phosphates are soluble and problems do not occur.

Scale. In the laboratory, the possibility of scaling is measured through the 'saturation index'. It represents the difference between the actual pH and the pH of water when it is fully saturated with Ca and/or Mg. A negative saturation index indicates the absence of scale forming and a possible tendency to corrosion. On the other hand, a positive saturation index indicates scale forming tendencies and protection from corrosion. High temperatures and heat may exaggerate the effect of the saturation index, and, if the hardness is present as carbonates, accelerate the precipitation of scale. Scale formation, when it occurs can cause reduced pipe flow rates, sometimes interfering with float valve and water medicator functions.

Excessive heat will also increase the rate of hydrolysis and breakdown of urea. There may also be some loss of added P when these scale problems occur. High levels of iron, magnesium and sulphur-dependent anaerobic bacteria in water can also cause scale problems and depress water intakes. These bacteria can be reduced or eliminated by oxidizing water through aeration.

pH and urea. In some water with high pH and high Ca levels, urea readily hydrolyses to ammonia, reducing urea levels in the concentrate. Sometimes there is also layering of urea levels in the concentrate tank (higher at bottom than at top of tank), particularly when there is slow turn-over of solutions in the tank.

In conditions of high temperatures, and waters with a very high pH and high EC, urea can hydrolyse during even short storage periods and during transit through medium to long (>3km) delivery pipe lines. The ammonia odour from urea breakdown can sometimes be detected in concentrate tanks and water troughs, and if pungent enough in the trough, can repel cattle and reduce their water intake.

Where layering is thought to be a problem, water can be taken from different levels of the concentrate tank or trough and tested with a Urea Test Kit (Gundrill Trading Pty Ltd, $270 including GST). If significant 'layering' has occurred, (urea concentration at bottom 1.5 times greater than at top) then remedial action, such as acid stabilisation, or regular mixing of the tanks, should be undertaken. These test kits can also be used to check that optimal urea levels are in the water at the trough where animals are drinking, though a note of caution that the readings may not be as accurate when testing surface water which may contain urease inhibitors (G. Murphy pers comm.).

<u>Acid additives.</u> There are basically three categories of acid suitable for neutralising pH in stock watering systems:

- food grade acids e.g. citric acids. These acids are too weak and will be ineffective except in the nutrient tank. Their only advantage is their palatability.

- phosphoric acid. This is generally used as urea phosphate, which when added to water, becomes phosphoric acid. The advantages of this supplement are that it supplies both N and P nutrients, while acidifying the water. The disadvantages are that it is expensive and additional P may exacerbate problems in some waters. However, if the water is effectively acidified, P solubility should not be a problem. The amount of urea phosphate required to stabilise the pH will vary from 10 to 75kg/1000L of concentrate, depending on the pH and bicarbonate concentration of the water. The early commercial grade black phosphoric acids used were unpalatable and depressed water intake and cattle production, but if given in the appropriate proportions urea phosphate does not have the same effect.

- hydrochloric acid (HCl). This is the cheapest and most effective acid and can be dispensed through an acid injector (Gundrill Trading Pty Ltd, $800; Norprim $975). It also has a neutral taste, and at suitable concentrations will de-scale pipes with carbonate and other scales. The disadvantage of HCl is that it is extremely corrosive and dangerous to handle.

Each water system is unique and the measurement of pH alone will not give sufficient information for the user to calculate the amount of acid required to stabilise the system. It is beyond the scope of this manual to outline all the possible options for adjusting water pH by acidification and specialist advice should be sought from manufacturers and suppliers of water medication equipment.

However as a general guide, the most effective procedure for adjusting pH if medication has started, is to stop the medicator, flush the system (including the nutrient tank), measure pH of the water and test with HCl (I Gundrill pers comm.). The HCl test requires adding HCl to a sample of trough water, or the trough and then measuring with a pH meter every 2 hours to see if the water responds to the acid treatment. If the pH does not continue to decline, either increase the amount of HCl or look at other alternatives to stabilise the pH.

These alternatives include the use of magnets (which may remove some of the buffers) together with HCl, regular flushing of the system, or the elimination of storage tanks containing medicated water (J Speed pers comm.). It may also be possibly to develop in-line monitors that measure pH. This approach is currently used in many local government water treatment plants (R Lascelles pers comm).

## Major ions of concern for livestock drinking water quality (ANZECC Guidelines 2000)

### Total Dissolved Solids (salinity) or Electrical conductivity(EC)

Total Dissolved Solids (TDS) or Electrical Conductivity (EC) are measures of all inorganic salts dissolved in water and are a guide to water quality. These measurements also include other dissolved substances such as organic compounds when present. The concentration of TDS in natural waters ranges widely, from <1 mg/L in rainwater to about 35000 mg/L in seawater, and higher in some natural waters. The major contributing ions are typically the cations Ca, Mg, Na and K, and the anions bicarbonate, chloride, sulphate and in some cases, nitrate. Water with a TDS > 15,000 mg/L is unsuitable for all stock. Recommended concentrations of total dissolved solids in drinking water for different livestock are given in Table 4.

**Table 4** Tolerances of livestock to levels of total dissolved solid levels (salinity) in drinking water.

| Species | Total Dissolved Solids (mg/L) | | |
|---|---|---|---|
| | No adverse effects Expected | Animals may have initial reluctance to drink, there may be some scouring, but dry mature animals should adapt without loss of production | Loss of production, decline in body condition and health expected. Dry mature animals may tolerate levels for short periods if introduced gradually |
| Beef cattle | 0-4000 | 4000-5000 | 5000-10000 |
| Sheep | 0-4000 | 4000-10000 | 10000-13000 |
| Horses | 0-4000 | 4000-6000 | 6000-7000 |

Water from artesian and sub-artesian ground waters is generally classified into 'chloride type' and 'bicarbonate type' waters (Feeding Standards for Australian Livestock. Ruminants. 1994; G Murphy pers comm). The principal component of TDS from bores in Queensland is sodium bicarbonate and in NSW and South and Western Australia is sodium chloride (Peirce 1966), whereas sodium was the dominant cation in most bore water samples from Northern Territory rangelands (Newman 1978). Intakes on water with high TDS may initially be higher as animals try to counter the effects of the 'salts', however feed intakes and production will be lower.

Surface waters generally have lower TDS concentrations than groundwater. In streams, dams and water troughs, TDS concentrations can increase due to evaporation, particularly if troughs are not flushed regularly.

Highly mineralised waters can cause physiological upsets and sometimes death in grazing animals under stresses such as pregnancy, lactation or rapid growth, since these classes of animals are particularly susceptible to mineral imbalances. Livestock generally find water of high salinity (1% NaCl is salty water) unpalatable. Water of marginal quality can cause gastrointestinal upsets, and reductions in weight gains and in milk production. However, animals can adapt to water of higher salinity provided increases are adjusted over several weeks.

Consumption of highly saline waters caused an outbreak of scours, ill thrift and deaths in weaners (salt poisoning) on a property in Central Queensland (Taylor 2001). The only signs at post mortem were digestive tracts full of watery contents. Water problems were suspected when weaners were provided with water from another source and intakes increased considerably. Analysis of water from the suspect bore revealed TDS levels of 16000 mg/L, though the same water had been tested previously and was 3000mg/L TDS.

The index of TDS is used throughout Australia as a convenient guide to the suitability of water for livestock. However, if water has purgative or toxic effects, especially if the TDS is above 2400 mg/L, water should be analysed to determine the concentrations of specific ions.

In natural waters, the electrical conductivity (EC, in dS/m) is directly proportional to TDS (mg/L) by a factor ranging from 550 to 900, depending on the types of dissolved salts present in the water. For convenience, TDS is often estimated from EC. The following is a useful conversion when interpreting water analysis data:

EC ($\mu$S/cm) x 670= TDS (mg/L).

TDS is also sometimes expressed as total dissolved ions (TDI), which is a summation of the concentrations of inorganic ions present in water, but does not include any other substances (e.g. organic compounds) that may also be dissolved in the water.

## Calcium and Magnesium

Livestock can tolerate Ca concentrations up to 1000 mg/L in water, if Ca is the dominant cation and dietary phosphorus levels are adequate. In the presence of high concentrations of Mg and Na, or if Ca is added to feed as a dietary supplement, tolerable levels of Ca in drinking water may be less.

Through its reaction with carbonates and other anions, Ca contributes to the hardness of water, which may cause scaling problems in pipes, troughs and fittings.

Calcium is an essential element in the animal diet. However, high Ca concentrations may induce P deficiency by interfering with P absorption in the gut and Ca deposition in the body.

Magnesium also contributes to the hardness of water and may cause scaling problems in troughs and fittings. If P supplements and urea are added to alkaline waters high in Mg, these can react to form extremely insoluble compounds such as magnesium ammonium phosphate, which can precipitate or form scales. If sulphate of ammonia (SOA) is added to water high in Mg, this can result in formation of magnesium sulphate (Epsom salts), causing scours in livestock.

High Mg concentrations in water are generally associated with high concentrations of TDS, hence many problems attributed to Mg may well be due to high TDS levels.

## Nitrate and nitrite

Nitrate and nitrite are oxidised forms of nitrogen, both of which can occur naturally in waters, although nitrate generally predominates. Both nitrate and nitrite can cause toxicity, nitrite being 10–15 times more toxic than nitrate. To become toxic, nitrate must first be reduced to nitrite (an intermediate product of the reduction of nitrate to ammonia) by bacteria in the rumen of cattle and to some degree in the caecum of horses.

**Nitrate** concentrations less than 400 mg/L in livestock drinking water should not be harmful. Concentrations of **nitrite** exceeding 30 mg/L may be hazardous to animal health.

Higher concentrations of nitrate and nitrite in water are often associated with over-use of nitrogen fertilisers and manures; intensive livestock operations; and/or leakage from septic systems and municipal wastes. Over-fertilisation with nitrogen fertilisers, or animal manures can lead to **excessive nitrate accumulation in plants**. Plants under stress (e.g. from drought), may also accumulate nitrate. High nitrate concentrations in water supplies may suggest that nitrate levels in locally grown feed could also be elevated.

## Sulphate

Sulphate is found in most natural waters as a result of the dissolution of sulphate-bearing minerals in soils and rocks. No adverse effects are expected if sulphate concentrations are less than 1000mg/L, though problems can occur at higher levels (1000 to 2000 mg/L), especially in young or lactating animals or when water intake is high in dry, hot weather. When deciding on the suitability for stock of water containing high sulphate concentrations, interactions such as those with dietary copper and molybdenum should also be taken into account.

Water sulphate levels greater than 2000 mg/L may cause chronic or acute health problems in stock, including scouring. This is because excessively high levels of sulphate ions react with Mg to form magnesium sulphate or Epsom salts. Extremely high sulphate concentrations in water (7200 mg/L) have been associated with polioencephalomalacia in cattle, with staggering, blindness, and death (Hamlen et al 1993).

Under anoxic conditions, bacteria in water can reduce sulphate to sulphide, which results in the release of hydrogen sulphide, causing an unpleasant taste and odour and increasing the potential for corrosion of pipes and fittings.

## Dissolved Oxygen

Most groundwater supplies, particularly artesian bores, are low in dissolved oxygen (DO). Low concentrations of DO allow growth of nuisance micro-organisms (Fe/manganese/sulphate/nitrate-reducing bacteria) causing taste and odour problems, staining and corrosion. Oxygen levels can be improved with the use of aerators on storage tanks, by creating a venturi or fountain effect in turkeys nests (inlet pipe at the bottom of the turkeys nest and pushes the water through a pipe to the top); by taking water from the top of the turkey's nest with a float valve on the outlet line; and by water entering the trough above the waterline.

# Organic contamination of water (ANZECC Guidelines 2000)

## Cyanobacteria (blue green algae)

Cyanobacteria (often called blue-green algae because they are similar to algae in habitat and morphology) are a component of the natural plankton population in healthy and balanced surface waters. Cyanobacteria only become a potential hazard when present in large numbers (blooms). Blooms typically occur on warm days with light to calm winds in waters of neutral to alkaline pH containing elevated levels of inorganic phosphorus and nitrogen, although blooms at other times are possible.

Not all blue-green algae blooms appear to be hazardous to animals (Carmichael and Falconer 1993), since:

- only low concentrations of toxins may be associated with the bloom.
- stock are not equally susceptible to algal intoxication; species, age and sex affect susceptibility, and
- the amount of toxin consumed may be small and/or countered by the amount of other food in the animal's gut.

The toxins associated with cyanobacteria only affect animals following direct ingestion of cells, or from drinking water where death of cells has caused a considerable release of toxins into the water supply. In the latter situation it may take weeks for toxins to be degraded by naturally occurring bacteria and therefore water can remain potentially toxic for some time (Carmicheal 1994, Jones 1994).

There may be some differences between animal species in the symptoms of toxicity but typically they include weakness, lethargy, loss of appetite, sometimes nervous signs, and often diarrhoea.

Since all blooms of cyanobacteria have the potential to be toxic and all livestock are susceptible, it is prudent to consider all scums as toxic until proven safe. A recognised authority on toxins is Dr Ross Mackenzie, Animal Research Institute, Queensland Department of Primary Industries and Fisheries, Yeerongpilly, Brisbane (Phone 07 33629400) who is an excellent contact for advice on algal or plant toxicity cases.

During 2001, *Cylindrospermopsis* poisoning, a form of blue-green algae, caused death and illness in weaners on a property in the Bauhinia Shire as a result of severe liver disease (Taylor 2001). This organism is widespread in freshwater sources in Queensland, but is not often reported as causing toxicity. Chlorination will effectively remove cylindrospermopsin from water.

## Other algal growth problems

There is a range of other algal species present in water sources that can occasionally create problems in stock water supplies, and in water storage and supplement concentrate tanks. Supplement concentrate tanks containing NPN and P sources often provide ideal conditions for algal growth. When displaced from either storage or concentrate tanks these algal clumps can interfere with water meter and water medicator function, and can sometimes grow profusely in troughs. As a consequence, the troughs have to be cleaned frequently. In-line filters control some of these problems. These issues are discussed in more detail in Section 5 of the Guide.

Algal growth can be reduced or prevented by:

- constructing deep dams with relatively small surface areas.
- ensuring good turn-over of water (at least 50% of water in the trough or tank daily, and preferably 100% twice a day with troughs).
- regular cleaning of troughs and concentrate tanks.
- application of copper sulphate at a rate of 1kg per Ml of water (copper sulphate is effective for only a few hours in alkaline water). However it is also important to ensure that copper based algacide treatment does not elevate water Cu levels above those recommended as suitable for animal health (Table 3).

- application of ferric alum reduces phosphorus concentrations and algal growths (place blocks in hessian bags and suspend these from floats at rate of 1kg ferric alum per 10,000L).
- using sealable polythene water tanks to prevent entry of UV light.
- flushing the water delivery system with chlorine, and
- application of magnets to the water delivery system

## Bacterial Pathogens

It is generally not feasible nor warranted to test livestock drinking water for the presence of the wide range of water-borne microbial pathogens that may affect stock health.

Though a large variety of microbial pathogens can be transmitted from drinking water supplies contaminated by animals and their faeces, there are usually not a lot of problems. The risk of contamination is greatest in surface waters such as dams and watercourses which are directly accessible to stock or which receive runoff or drainage from intensive livestock operations or human wastes.

The incidence of groundwater contamination by pathogens is generally low, particularly for deep bores and wells. Waters high in Fe, Mn and S may encourage bacterial growth, and some bacterial species use Fe and Mn for energy. Iron dependent bacteria can often be found in bores and can block filters (R Lascelles pers comm.). Polythene pipe lines may also harbour organic growth, particularly when water contains added P, and where pockets of air accumulate due to irregular laying of the pipe (I. Gundrill pers comm).

Management of water supplies to minimise contamination is the best strategy for protecting livestock from water-borne microbial pathogens.  These management strategies include preventing direct access by stock to watercourses and minimising drainage of waters containing animal wastes to streams and groundwaters. Without specific testing procedures it is difficult to identify whether there is bacterial contamination within the algal blooms. It is assumed that by controlling the algal blooms, bacterial contamination is also reduced.

# Heavy metals and metalloids (ANZECC Guidelines 2000)

## Cadmium

Cadmium concentrations in surface waters are usually extremely low (<0.001 mg/L). In unpolluted streams cadmium occurs predominantly in association with suspended particulate matter, rather than in the dissolved state. Cadmium concentrations greater than 0.01 mg/L in water for livestock may be hazardous, given the fact that cadmium accumulates in the liver and kidney from long-term exposure with potential human health risks.

NRC (1980) suggested a concentration of 0.5 mg/kg as the maximum tolerable dietary intake. However only a small amount of the total cadmium intake comes from drinking water. Most cadmium intake comes from food and supplements e.g. fertilisers contaminated with cadmium fed as P supplements. Nevertheless, cadmium concentrations in drinking water for livestock should be restricted because of toxic and possible deleterious effects in humans (CCREM 1987, CCME 1996).

## Fluoride

Unpolluted surface waters generally contain low concentrations of fluoride (Fl) but concentrations in groundwater may be higher in some areas. Groundwater Fl concentrations more than 2 mg/L have been reported in the Great Artesian Basin in Queensland, with a few bores containing more than 10 mg/L (Gill 1986). QDPI&F have available detailed maps of Qld and the NT outlining bores with high Fl content unsuitable for stock. In Queensland the areas affected include the Carpentaria Basin in the Gulf; south-western Eromanga Basin in the southern Channel country; central eastern Eromanga Basin near Longreach and the Surat Basin around Roma.

Fluoride accumulates in bones rather than in soft tissue and excess Fl (more than 2 mg/L) can result in tooth damage to growing animals and bone lesions in older animals, while levels more than 5 mg/L adversely affect breeding efficiency in cattle (VIRASC 1980).

Many P supplements, particularly P fertilisers, contain high levels of Fl, and those with more than 50mg Fl/g P are unsuitable for long-term use. Technical grade fertilisers generally contain lower levels, and are recommended for this reason. If supplements being used contain Fl, the trigger value for F levels in water should be reduced to <1.0 mg/L.

Certain symptoms of P deficiency are also common to fluoride toxicity (fluorosis). These include shifting lameness, staggers and poor condition. Water, feed and animal tests must be carried out to identify the cause and implement the appropriate solutions.

On "at risk ' properties, the risk of fluorosis may be avoided if sufficient supplies of water low in fluoride (e.g. surface water) are available, and if livestock on a property are located so that young animals have access only to low fluoride water early in life. Fluoride concentrations in water are rapidly increased by evaporation, such as occurs when artesian bore water is reticulated through shallow bore drains. In these situations young stock should be watered as near to the bore head as possible, on water with the lowest Fl levels. Control measures are less important in good seasons when stock can access the bulk of their water requirements from pastures or available surface water.

## Other minerals

Zinc and nickel levels in water have been reported to reach toxic levels from corrosion of zinc coated plumbing, galvanised iron water tanks, or corrosion of nickel plated fittings, particularly in waters of low pH.

Several heavy metals and metalloids such as arsenic, selenium, uranium, molybdenum and mercury may reach toxic levels in water near areas of mining, industrial activity or mineral processing adjacent to cattle grazing areas

Many metals interact, for example Cu and Mo, Al and P. Excessive levels of aluminium in water may induce P deficiency.

Problems of excess metals are influenced by soil and water pH, for example excess Al is mostly seen in soils of low pH.

Farming activity history is also important. Pesticides and fertilisers may contain boron and molybdenum. Old sheep dips and some current herbicides may contaminate water supplies with arsenic.

Some metals eg Mn and Fe may be found in high concentrations complexed with organic matter, or under anoxic conditions (eg in groundwater or in lower strata of deep dams). These elements **may** indicate adverse conditions but in themselves they are rarely toxic.

Toxicity of minerals can depend on their form; for example copper chloride is two to four times more toxic than copper sulphate.

# Mechanisms for modifying or improving water quality

While water quality is an identified problem in some areas, and requires further work, the more important step is in finding solutions to improve quality, thereby enhancing water intake, improving the efficiency of water medication and improving animal performance.

Information on techniques and technologies designed to improve water quality is vast, particularly information on technologies for improvement of water for human consumption. However the claims made for some techniques are dubious

It is not possible in a manual of this type to describe or to judge the worth of all available techniques, but rather to list and briefly describe some of the more commonly used approaches.

## Chemicals

As mentioned previously, acidifiers such as HCl or urea phosphate, and other compounds such as copper sulphate and chlorine all have application in certain circumstances. However from a practical and environmental viewpoint, chemical treatment to improve stock water quality has only limited application.

## Magnets

The subject of antiscale magnetic treatments and other physical methods of scale suppression remains controversial, and these are still labelled as gadgetry in some scientific circles (Parsons et al 1997). While most chemists, scientists and physicists still do not understand, or cannot agree on why magnets work, many producers are saying *' why get hung up on the why if it works'*.

Many devices on the market have reasonably good track records, but even these have occasionally proven ineffective in some situations. Many designs of commercial magnetic treatment devices (MTDs) are available. Some use electromagnets whilst others use either single or arrays of permanent magnets. Other MTDs are clamped on to the pipe, but these typically display lower field strengths than the plumbed in variety.

In the last couple of years in Australia, the use of magnet technology to enhance water quality has increased substantially. The magnets predominantly used are permanent magnets clamped on to the pipe and well earthed. In reviewing the literature, Parsons (2001) concluded that most successful applications of MTDs have occurred in continuously recirculating systems enabling repeated treatment of the processed water.

Magnets (red) attached to outlet pipe from bore head with coiled earth wire shown attached to earth stake.

It is fairly well agreed that the anti-scale effect of magnets results from changes in crystallisation behaviour promoting bulk solution precipitation rather than formation of adherent scale. The magnetic effect also appears to be enhanced when there is a high mineral load in the water.

Credible laboratory studies have shown increased solution precipitation rates, changes in mineral crystal size and morphology and retention of the anti-scaling properties of water for hours or days following treatment. In many of these studies, the results have only been apparent under dynamic magnetic treatment, i.e. when solutions are moving sufficiently rapidly through the magnetic field.

Many mechanisms for the anti-scaling effect have been proposed. Some are clearly illogical eg magnetically induced changes in electron configuration (this would require a huge field). The mechanisms of action of magnets applied to rural water pipelines are claimed to be that the high performance magnetic energy enhances anion-cation exchange, rearranges the molecular structure of the fluid (north/south), transmits positive energy to the water and reduces surface tension of water molecules. Some of these claims would be hotly disputed by scientists involved in domestic water treatment programs.

No hypotheses are fully comprehensive and can account for all of the observed effects (Parsons 2001). However one thing is for sure - there is an interaction between a magnetic field and crystallising matter which can, on occasions, affect its scaling behaviour.

The most commonly used magnet for water treatment in rural Australia is the Fluid Reactor™ marketed and installed by Gundrill Trading Pty Ltd. Prices range from about $150 for booster magnets to $1,600 for large units for 100mm pipes. The specific objectives and descriptions of action of these magnets as claimed by the company are to:

- prevent calcium carbonate and other mineral scale formation through enhanced anion-cation exchange. After magnet application, in some cases water quality can get worse for a short period as the magnet effects are stripping all scale off the pipes. This can appear in the form of ‘snow’ on the lawn or the pipes may even block up. However, in other water systems the scale will dissolve and there are no problems. Water quality should be tested about 6 weeks after installation of magnets.

- kill algae and associated bacteria. Magnets prevent algae growth in 70 to 80% of cases as algae theoretically cannot survive in positively charged water. They specifically reduce iron and magnesium dependent anaerobic bacterial growth and algal growth in water that has added nutrients, perhaps through effects of magnetic radiation on cellular structures. Bioslime is a slimy residue of bacterial and algal cells. Magnetic effects are said to dissolve the bioslime that houses the bacteria allowing contact with chorine for sterilisation.

- dissipate chlorides through transmitting positive energy to the water.

- reduce EC levels in the water. Salt can be reduced if there is adequate Ca in the water.

It is claimed that if these objectives are achieved, livestock water consumption will increase, plant growth will improve through better moisture absorption and hard water becomes soft and actually has a ‘lather’.

Magnets are not expected nor claimed to stabilize pH or prevent iron oxide (red staining) formation. Through their anion-cation exchange mechanism, magnets may actually increase the amount of red oxide, particularly when water turn over is poor.

Livestock producers who have used magnets to enhance water quality in a number of situations where magnets had been successful, specifically high EC levels and excessive algal growth, with extremely low water consumption rates in weaners of 8L/day. After applying Fluid Reactor™ magnets, consumption increased to 25L/day, and there were lower day to day fluctuations in water consumption. However several other magnet users did not believe there were any improvements in water quality when magnets were used in their situations.

There are different sizes and types of the Fluid Reactor™ range, which is claimed to have some specific advantages over normal magnets, and selection of size and type depends on EC level, position of magnets and size of pipes. The installation procedure involves placing two magnets on either side of the pipe and connecting the magnets to an earth wire leading to an earth stake. The soil around this 'earth' should be kept moist. Fluid Reactor's™ are installed 'after storage and after pumping', therefore if the bore feeds to several storage points, a large Fluid Reactor™ is installed at the bore and smaller magnet boosters are installed at each of the storage points.

## Other devices

A number of other devices are on the market that are claimed to improve water quality. Some, such as the Water Wizard (Nutri-Tech Solutions P/L; 0754729900; $870) and WaterPure, are claimed to induce a vortex type effect on flow patterns of water in a pipeline, reducing ion precipitation, and build up of scale, thus improving flow efficiency. Others, such as the CALCLEAR ® water conditioner, use ionisation by electromagnetic induction. This is claimed to change the ability of calcium ions to crystallise, thereby minimising scale formation. Again, anecdotal evidence suggests that these and other technologies may work in some, but not all, situations to enhance water quality for cattle.

There are a number of aerators (see previous photo) on the market (e.g. Gundrill Trading Pty Ltd - prices $165 to $850) that are claimed to improve Dissolved Oxygen levels in artesian waters.

A water flavouring product STOC-JOY® is available which contains a mixture of electrolytes and flavouring agents, and is claimed to mask unpleasant tastes in water. It has been used to increase water intake in cattle in holding depots for export, and may also have some potential for use in medicators for yard weaning of cattle. However, price and practicalities may preclude use of the product in medicators in paddock situations where water quality is a problem.

At the moment the approach to modifications of water quality is very much 'suck it and see', which can be time consuming, sometimes costly and sometimes ineffective.

In summary, while these different technologies are not a cure for all water problems they may be an effective answer in some situations. There is a need for some critical analysis of all situations where the technologies have worked effectively and more importantly, where they have not. In this way it may be possible to identify the factors that are crucial to successful application. However regardless of the outcome of any investigations and debate on water modification devices, the benefits of non chemical as against chemical water treatments are obvious, from OHS and environmental points of view.

# SECTION 5. WATER MEDICATION TECHNOLOGY AND EQUIPMENT

## Some background on water medication

By far the most common use of water medication is to provide N, S and P supplements at critical times of the year. However a range of other products and substances including trace minerals, electrolytes and sugars, flavouring agents, seaweed extracts, bloat control oils, energy sources and some organic internal parasite control substances have also been provided to cattle though water medication.

Although water medication technology was first developed and used almost 25 years ago, earlier systems had some problems. Most early dispensers worked on the mechanical principle of a tipping bucket where supplement or additive flow to a bucket was at a rate controlled by water flow into the trough. At a certain mass, the bucket tipped, discharging the supplement or additive into the trough. The other bucket commenced filling and the cycle of filling and discharge continued. Whilst many claims were made regarding efficiency and safety of these devices, they were often inherently unreliable, with a high risk factor. Consequently this type of medicator, and the technology in general, fell into disfavour with most producers, and it is only in the last 10 years that water medication has again become more widely used. This has been due to the development of improved, more reliable and safer equipment, recognising the importance of human factors in function and safety, and the identification and use of better forms of supplements.

Another very important point to note is that water medication has only been really successful in the hands of producers convinced of the value of the technology in enhancing their operations. These people have been prepared to learn and understand the principles and mode of action of medicators, the safety margins and potential risks and to accept the need for frequent and ongoing monitoring of water points, equipment and livestock.

## Advantages and disadvantages of water medication

Water medication **cannot be used in all situations** to provide supplements to livestock, nor can it, **nor should it be used by all producers**, who will have a range of different attitudes, skills, and financial and production objectives.

Any decisions to introduce water medication should be based on an assessment of how, or if, it will benefit a particular operation, and the pro's and con's of the technology need to be weighed up carefully.

Some of the advantages and disadvantages of the technology are listed below.

Advantages include:

- all animals drink water and thus consume the supplement, provided no alternative water sources are available.
- water intake is proportional to body size as are nutrient requirements, and thus supplement intakes of the correct concentration will meet nutrient requirements.
- intakes should be more uniform across a mob, as animal and supplement factors including shy feeding, bullying, supplement acceptability and palatability are not issues.
- supplement costs are lower than traditional supplementation strategies, since there is no need for carrier substances such as molasses and salt.
- less time is spent by cattle around watering points as there no attractants such as lick blocks.
- potential lowering of labour costs for supplementation, though experience suggests these savings may not be great, as time spent monitoring and maintaining dispensers and concentrate tanks is probably similar to the time involved in loading and transporting other supplements.
- better recognition of importance of water consumption and water quality on production, although this impact has only been seen more recently.
- reduced 'wear and tear' and maintenance costs on vehicles as the amount of supplement fed is up to 50% lower than that required for dry licks or blocks, and
- ability to deliver other water soluble substances including sugars and electrolytes, and potential in the future for delivery of other substances.

Disadvantages include:

- can only be utilised where no surface water available.
- additional capital investments in equipment and facilities.
- high level of management and technical skills required.
- increased risk factor where there is low skills base in staff operating and maintaining medicator.
- potential mortalities from urea toxicity (human error or medicator malfunctions). Urea toxicity can also occur when feeding dry lick or blocks (Section 2).
- possibility of supplement losses from water due to water quality problems.
- only supplements soluble in and remaining stable in water can be fed.
- ongoing and continuous supervision and monitoring required.
- objective data on medication responses very limited, though if animals receive the same amount of urea, irrespective of the method, responses should be the same, and
- benefit: costs of the technology  not well established for all regions.

To repeat:

Water medication technology can be used in most grazing situations where water supplies are **fully controlled**, and **preferably the only water source available** is via a trough.

The technology cannot be used safely and efficiently when stock have access to alternative non-medicated waters such as dams, springs and water courses.

Where stock have access to other waters they will be **unable to obtain sufficient intake of supplement** from a medicated water supply to achieve a benefit.

More importantly, there is a **high risk of toxicity and mortalities** when animals with access to other water consume their full water requirements from a medicated source, as their **metabolism will not be adapted to the sudden high levels of urea.**

## Who can or should use Water Medication

Those producers who are successful users of water medication tend to have a number of characteristics in common including:

- a wish to improve herd production levels using a range of technological and management strategies including strategic supplementation.
- a high level of management expertise.
- a good technical background and knowledge to understand equipment operations and maintenance requirements.
- a preparedness to make strategic investments in new or modified water supply facilities of a good standard (not doing things on the cheap).
- an understanding of nutritional principles, and the ability to identify which, when and how limiting nutrients can be provided.
- a commitment to regular monitoring and recording of medicator operations and of cattle performance, and
- a recognition of potential hazards of the technology and how these can be minimized (vigilance).

## How medicators work

There are currently two major types of medicators on the market, and being used by producers. One type is a fully **electronic proportional dispenser**.

Norprim Unit


The other less commonly used type of medicator is a **water pressure driven proportional injector.**

Dosatron

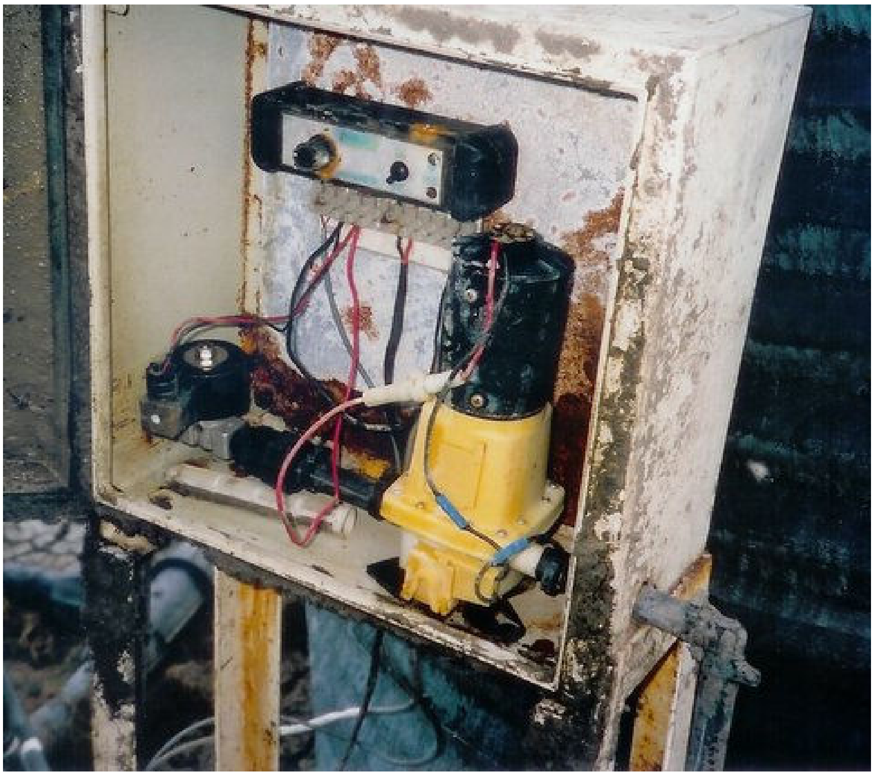
Units are usually located near the water supply source (bore, tank, turkey-nest, dam), and close to a small (500-4000L) nutrient concentrate tank connected to the dispenser. The dispenser unit is set up to inject nutrients directly into the line supplying one or more troughs. These supply lines are generally gravity fed where the source of water is sub-artesian or ground water. Alternatively, with the high pressures in piped artesian water supplies, or in situations where the fall of the land does not allow a gravity feeding set-up, the water may be delivered to the troughs under pressure.

In other installations, where water is being pumped via a distribution system to water points servicing a large area, dispenser units and concentrate tanks have been located at a central point and medicated water is pumped either to storage tanks or to troughs servicing different paddocks.

Norprim unit, showing pump, solenoid, control box and 12v power source


Newer type Norprim unit with solar panel mounted on roof of protective box.

Nutridose unit opened showing electronic control panel, pump and solenoid valves, with instructions on door of box.

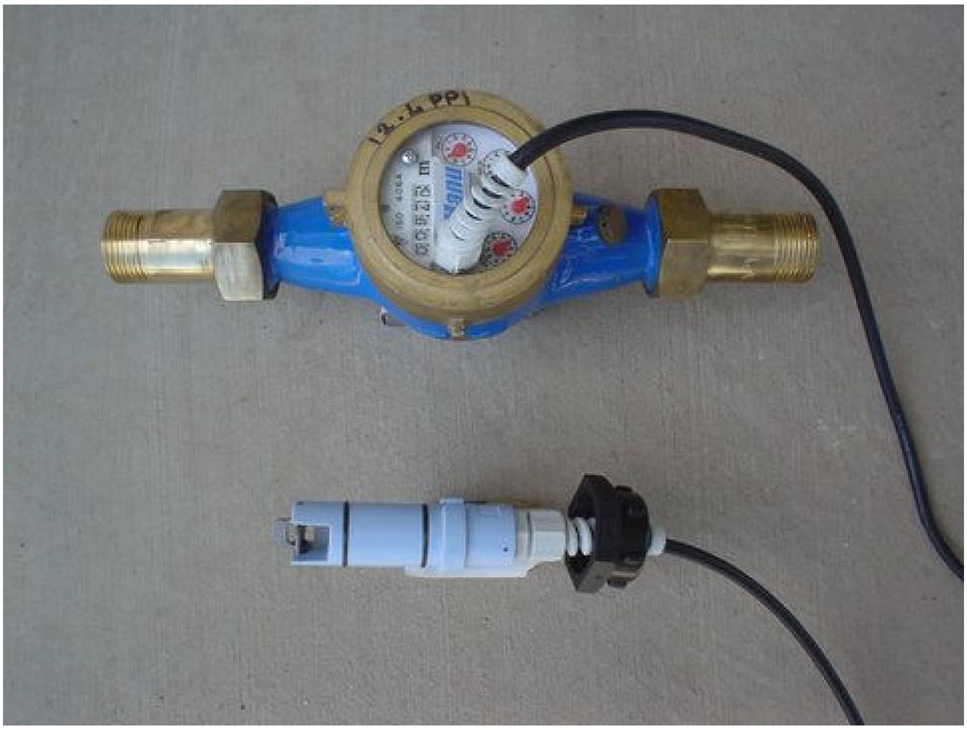


Regardless of the type of medicator used, it is important to protect the unit and other equipment such as concentrate tanks and solar panels from livestock and wildlife.

A number of producers using water medicators with grazing management systems where cattle are moved onto other water sources frequently have installed medicators and equipment so that they are easily movable.

## Electronic Dispensers

The most commonly used brands of fully electronic proportional dispensers at the moment are the NORPRIM® and NUTRIDOSE® medicators (See Table 5). In both these electronic dispensers a small electric pump is used to inject an adjustable amount of nutrient concentrate into the pipeline or water trough. A paddle-wheel flow sensor in the line or a turbine flow meter in a mechanical water meter measures water in-flow in the supply line, and sends an electronic pulse to trigger the nutrient pump. The pump timer is adjustable to vary the amount of nutrient concentrate injected into the watering system. In some models, water consumption data is electronically measured and logged, while in others it is measured using a mechanical water meter, which requires manual logging of data. Some types of mechanical water meters can restrict water flow depending on pipe size. Medicator manufacturers can provide advice to producers on appropriate water meters for their operation. In some units, producers will read the amount of water used off the electronic unit and then confirm it by manually checking the water meter. Medicator units are available in different sizes dependent on flow rates, water pressure and numbers of animals being supplied.



White coiled cable attached to water meter is attached to paddle wheel flow sensor in pipeline and sends electronic signal to dispenser to activate pump, the paddle wheel sensor below the water meter can be connected directly into pipe line and sends electronic signal to dispenser to activate pump.

These units have a variety of different safety features, including electronic cut-out valves and anti-siphon devices to prevent concentrate loss through malfunction. These safety devices minimise possible hazards caused by over-supply of concentrate. Power is usually supplied by a 12 volt DC battery, often recharged by one or more solar panels. The amperage of solar panels will vary depending on the size and brand of the medicator, and advice should be sought from the manufacturer. Solar panels should not be used for dual purposes such as powering an electric fence energiser. In one case where this was done, there was a malfunction of the medicator unit and pumping of excess amounts of nutrient concentrate into the water supply occurred. In some cases 12V power is supplied from a mains supply battery charger, and 240V models are also available.

In more recent models, provision is now being made for electronic circuitry to link with telemetry equipment to activate alarm systems in the event of malfunction and to enable remote sensing of tank, trough and concentrate tank water levels, as well as dispenser operations and nutrient concentrations in the water trough.

Some producers have made minor modifications to these units. These have included:

- installing an in-line filter on the pump inlet line to minimise pump diaphragm wear and damage due to crystallisation of nutrients.
- installation of isolator switches to enable line purging with clean water.
- minor modifications on the outflow side between dispenser and trough to allow calibration of pump dispensing rate and checks on pump function.

With electronic units, there have been reports of damage to exposed cables between the power source and dispenser, and between the water flow meter and dispenser, as a result of birds and dingoes chewing cables. Some shielding or protection of cables may be necessary and is strongly advocated.

### Water Pressure Powered Dispensers

Several types of water pressure powered proportional dispensers are on the market, of which the most common is the DOSATRON ®, though some DOSMATIC ® units (Table 5) are still in use. A water powered unit manufactured by Gundrill Trading Pty Ltd, and designed specifically for use with liquid supplements (not suitable for urea) has recently come on the market, but there is little information on performance characteristics at this stage. The concept for the DOSATRON ® and DOSMATIC ® units was originally developed in France for supply of fertilisers through irrigation water in some plant industries and for supplement and animal health product delivery in the intensively housed pig and poultry industries.

These units have been widely used for grazing livestock in Australia in the past, and are still the preferred choice of some users concerned at the possibility of electronic breakdowns in other types of units.

Dosatron water powered dispenser


Dosatron water powered dispense

The units utilise a water-driven reciprocating piston to inject the concentrate solution into the water line, proportional injection of the nutrient concentrate being governed by flow rate of water into the pipeline or trough. Although both high and low-pressure units are available, they still require a pressure head for operation. Water intake is monitored usually using a mechanical water meter, and intake data has to be logged manually. Safety devices usually fitted include an in-line filter on the inlet side and an anti-siphon device. Some producers bury the nutrient tank, and have the DOSATRON ® unit and nutrient tank below the storage tank to provide a pressure head and to prevent siphoning.

There have been some reports of malfunctions due to excessive wear of the plastic cylinder and piston as a result of sediments in the water. Stainless steel pistons and cylinders, improved seals and extensive filter systems that are regularly cleaned are reported to minimise this problem. Progressive deterioration of the plastic casing of the DOSATRON ® medicator can occur when exposed to long periods of solar radiation, though this can be minimised through protective shading of the units.

Because of their reliance on a good operating pressure head, these types of units are not appropriate for all stock watering systems, or where water consumption is low and the units are only operating intermittently. However, they are preferred by some operators with adequate water pressure, due to their mechanical rather than electronic nature, and some of these users believe that there are greater safety concerns with the electronic units.

## Potential hazards of water medication caused by technical and equipment problems

### Corrosion problems

Regardless of the type of unit, there are potential problems with the corrosive nature of some concentrated nutrient solutions used for supplementing livestock. Solutions containing urea, sulphur and some phosphorous sources can be extremely corrosive under some conditions, particularly when prepared with poor quality water.  Corrosion damage to metal pipes and fittings and some pump components can occur, leading to unit malfunctions.

Polythene delivery systems rather than metal pipes and fittings should be used. An in-line filter on the inlet line from the concentrate tank is usually installed to remove sediment and crystals from the concentrate before it enters the pump. It is not possible to be specific about issues such as pipe size and grade, as this will be dependent on a range of factors such as numbers of stock watering on a trough or tank, trough capacity and water pressure. However as a general rule, when using water medication, scale formation in pipes is less of a problem in larger than in smaller diameter pipes.

Concentrate solutions remaining in the lines and pump at the end of the season may sometimes crystallise, causing pump damage. Pre-shutdown flushing of lines and pumps with fresh water is a recommended maintenance procedure. Some users on poor quality water have modified units to incorporate an isolation switch that enables the pump and lines to be purged with fresh water regularly to remove sediments.

The electronic NORPRIM® and NUTRIDOSE® units are sealed units designed to prevent nutrient solutions leaking onto or around the electronics. The most recent models also have the controls set vertically so any contaminant liquid is more likely to drain away. Other preventative devices such as an automatic closing lid are also installed. Despite the safeguard features, **care needs to be taken while handling or adjusting the controls** to avoid nutrient solutions contaminating the units. Routine care and maintenance of all units is a **MUST**, to minimise malfunction problems.

## Concentrate tanks

**Light coloured, sealable squat polythene** concentrate tanks are preferable because:

- they will minimize corrosive effects of some concentrate solutions
- reduce evaporation losses
- inhibit algal growth by reducing UV light penetration
- reduce water temperature of the concentrate solution
- due to their shape and height they are easily accessible for mixing, cleaning and checking.

While dark polythene tanks will reduce UV light penetration even further, they have the disadvantage that concentrate temperatures can get higher than in light coloured tanks. This is important when poor quality water has to be used, since hydrolysis of urea (and loss as ammonia) in poor quality waters is accelerated by high temperatures.

There is some debate about the best size for concentrate tanks but a good principle is that **the quicker the turnover of the nutrient concentrate, the better**. Concentrate tank size will be dependent on mob size, but should be sufficient to contain enough concentrate for 7-10 days, most being about 900-1100L (Approximate costs $360-$460, at June 2004).

As an example of determining tank size requirements, at the concentrations commonly mixed, to supply 50g urea/head/d requires approximately 15L concentrate/100head/day. On the basis of 500 head watering at the medicator this equates to approximately 75L concentrate per day or about 750L for a 10day period. In this type of situation a 900L (200gal) tank would be the best option.

## Importance of concentrate mixing

In many situations it is important to **regularly and frequently mix** concentrate tanks, particularly when using poor quality water where some sedimentation of nutrients is occurring. While some users mix the tank manually with a paddle, many others use a portable fire fighting pump that gives quicker and more thorough mixing. One producer puts the hose from a fire fighting pump into some tubing in the nutrient tank, which creates a venturi effect which gives more efficient mixing. Another producer who had some sedimentation problems has custom designed his nutrient tank. It is a plastic silo cone Clark tank with the inlet pipe going in at the bottom so mixing occurs as the tank is filled.

Several operators who have had sedimentation problems have used a small 12V submersible marine pump powered by the dispenser power source, and activated by a household electricity mechanical timer device, for regular agitation of the concentrate solution. Others use an electrical pump connected to the concentrate tank, which is connected to a timer device, ensuring regular mixing of the concentrate.

Post mixing, it is advisable to use a gauze scoop to check for any undissolved crystals in the nutrient tank. This scoop can also be used to remove any contaminants that float to the surface (see earlier photos).

## Algal and bacteria growth

In some situations, and with some water, a combination of additional N and P nutrients can stimulate algal growth in concentrate tanks, troughs and sometimes in storage tanks containing medicated water and that are exposed to sunlight. This algal growth will reduce nutrient concentrations in the medicated water, and as mentioned in Section 4, some types of algae also produce toxins harmful to livestock. There have also been occasional reports that excessive algal growth in turkey nest and other storage tanks has caused water meter and dispenser unit malfunctions, though an in-line filter should overcome some of these problems.

Some approaches to algal and bacterial growth are covered in Section 4.

## Calibration of equipment and calculations of supplement requirements

Producers should follow the manufacturers recommendations on equipment calibration and calculations of dose rates of supplements.

The following information is provided as an **example** of a manufacturers recommendations:

Guide to Nutrient Usage (extract from **NORPRIM Nutrient Dispenser Installation and Operating Manual)**

*Mix 40kg urea and 10kg sulphate of ammonia to 150L water to make up 200L nutrient mix. (assume 1kg = 1L)*

*Thus 40kg urea in 200L nutrient mix is equivalent to 40,000g urea in 200,000ml nutrient mix or 1g urea in 5ml nutrient mix.*

*Pump operation is 100ml nutrient mix per second (although this needs to be monitored and some pumps can deliver up to 120ml). If 5ml nutrient mix contains 1g urea, 100ml nutrient mix (or 1 sec of pump cycle) contains 20g urea.*

**Formula** for setting water flow on the unit:

Number grams urea in 1 second of pump cycle X Av daily water intake

*Number grams urea to be fed/hd/day*

***Assumptions:***

*From above, known concentration of urea is 20g/1sec pump cycle*

*Av daily water intake (taken from water meter) = 30L*

*Number grams urea to be delivered = 20g*

*Then* $\frac{20}{20} \times 30 = 30$

*Thus set unit for water flow, 30L against pump cycle 1 sec. The answer from this formula* ***always*** *gives the required water flow setting against 1 sec of pump cycle.*

*As daily water intake decreases with cold weather, eg 18L/hd/day and feeding level is increased due to reduced quality of pasture, for example 40g urea/hd/day.*

*Then* $\frac{20}{40} \times 18 = 9$

*Thus required water flow is 9 L per 1 second pump cycle. In this instance, because of increased pump initiation it is advisable to set alternatives such as 18L/2sec; 27L/3sec or 36L/4sec. This will achieve the same concentration of urea in the trough but put less demand on the pump and system due to fewer 'stops' and 'starts'.*

It should be noted that other types of units, such as NUTRIDOSE, do not calculate dose rates based on pump cycles. The newer units in this brand express the dosing ratio in percentage. Therefore, when the dosing ratio is set at 1%, the unit will deliver 100ml per 10L water. Similarly, the cut off is expressed as percentage and when set at 1.10%, the unit will cut off at 110ml per 10L of water flow.

Users should have a thorough understanding of the calibrations and calculations involved and ensure these, and matters of basic equipment methodology, are also understood by other operators. This understanding will minimise the chances of human error in calculations and operations that has caused a number of mortality events.

These records allow Operators to **monitor NORPRIM performance** by comparing the number of notches the mix has **actually** gone down since last filled with the amount that **theoretically** should have been used. The theoretical use is calculated using water flow, flow rate settings, number of seconds/pump and theoretical volume/notch.

A useful matrix outlining grams urea/L delivered at 1 second intervals for every 5L change in water flow settings. These are easily developed in spreadsheet software programs such as Microsoft Excel, and can include costs. For each season and similar numbers of cattle, the concentration and mixing formula in the nutrient tank remains the same and the water flow per pump cycle (L/sec) is varied to change the amount of urea delivered per head.

Robert & Beannie Mackenzie successfully use a **NORPRIM unit** on "Moyallen" near Morven SW Qld has Norprim units at either bore heads (high pressure type) or at turkey nests (both high and low pressure types) with different size concentrate tanks at different installations. Varying instructions are written out for each size concentrate tank or NORPRIM type. An example follows.

## Tank filling procedures

- Turn off tank outlet
- Measure and write down amount in tank (using notch stick, calibrated in cm from bottom)
- Decide how many cm of water you are putting in tank and how many bags of supplements are needed.
- Put shade cloth strainers over filler hole, and empty one bag into shade cloth.Turn on water and wash supplement into tank until desired number of bags is added
- Fill tank to required level.

## Checking and cleaning

- Unscrew and clean in-line filters and replace
- Check lid is back on tank to prevent light getting in
- Check count the number of empty bags put into tank, and record all details in book in red.
- Check NORPRIM is reset and record settings.

Individual users will have slightly different procedures for calculations and checking of operations. However the critical points that were identified by most successful users of water medication are to establish a standard method each time medicators are serviced, to maintain good records of what has been done, of water consumption patterns and of numbers of cattle on a particular medicator. Should the unforseen happen and some mortalities occur, then analysing these records should help in understanding what has gone wrong and minimise the chances of them recurring.

## *Currently available equipment, suppliers and current prices*

The table on the following page lists some details on sources of supply and current (June 2004) prices for the most common water medicators currently being used in the beef industry. Prices indicated are for base units and more information on other equipment costs can be obtained by contacting suppliers.

Table 5. Sources of supply and approximate costs of common water medication units

| Medicator | Supplier | Contact Details | Price at June 2004 |
|---|---|---|---|
| NORPRIM ® | Norprim<br><br>(Mr A McEvoy; Mr J Dobbins; Mr M Peart) | PO Box 87<br><br>Mitchell, Qld 4465<br><br>Ph 07 46231141<br><br>Fax 07 46231941 | Base Unit $2600 |
| NUTRIDOSE® | Pastoral and Feedlot Systems (Dr T Wood; Mr N Bashford) | 17 Railway Rd<br><br>Fairfield, Qld 4103<br><br>Ph 07 38485290<br><br>Fax 07 38485231 | Base Unit $2900 |
| DOSATRON® | Hortec Dosing Systems<br><br>(Mr K Nicol; Mr R Young) | Factory 4<br><br>152 New St<br><br>Ringwood, Vic 3134<br><br>Ph 03 98769355<br><br>Fax 03 98769354 | Base Unit $2300 |
| DOSMATIC® | IMEXCO Aust Pty Ltd (Mrs S Johnston) | Lot 2, Winta Rd,<br><br>Tea Gardens NSW 2324<br><br>Ph 02 49972045<br><br>Fax 02 49972085 | Base Unit $550 |
| LIQUID NITROGEN DISPENSER | Gundrill Trading Pty Ltd (Mr I Gundrill) | PO Box 534,<br><br>Arundel, Qld 4212.<br><br>Ph 07 5563 3335<br><br>1300 888 008<br><br>Fax 07 5563 3443 | Base Unit $2000-2200 |

Inclusion of suppliers and equipment in the above table does not imply any approval or warranties by MLA of the equipment listed.

Some points to keep in mind, in addition to price, when selecting a particular unit include;

- reliability of units (check with other users).
- level of technical support provided.
- after-sales service and maintenance including trouble shooting.
- availability of spares and of spare units for use during breakdowns.
- complexity of units, and ease of on-property trouble-shooting.
- whether units suit existing water supply situations eg water pressure, pipeline sizes.
- reliability of safety devices and cut-off switches.
- ease of setting up dispensers, and
- ease of calculating concentrates (manufacturers specifications should be followed).

# SECTION 6. SUPPLEMENTS

This section provides some information on supplements currently used by producers using water medication, together with information on current (June 2004) prices and availability. The latter figures are of course subject to change.

## Background to current supplement usage through water medication

Keith Entwistle interviewed producers in central Qld inland in a loop from Rockhampton to Longreach and back to Townsville, in the Northern Territory (Top End: Alice Springs), and in NW Western Australia. Supplement usage was as follows in the sample of producers interviewed:

About 60% were using home brew mixes of urea/SOA in the dry season with those in P deficient areas also using P (MAP) in the wet season (and some in the dry also), though a few of these will probably switch to prepared mixes as below. About 30% were using prepared mixes including Nutrifert (PFS 3), Norprim mixes or Growforce Flowfeed products. About 10% were using or had used Liquid N, though at least two of these had problems with the mixture going off in the tank probably due to poor quality water. Included in the above were a couple who have used the Virbac trace element mixes as well.

Similar numbers of producers were using either NORPRIM or NUTRIDOSE units, a small number were using DOSATRON units, and one producer continued to use a DOSMATIC unit with which he was very satisfied.

**Sandi Jephcott interviewed producers in south east and western Qld;** the Collinsville area and in the Gulf and western Gulf. Supplement usage was as follows in the sample of producers interviewed:

About 50% were using home brew mixes of urea/SOA (and sometimes P) in the dry season; about 30% were using prepared mixes with the majority of these using the Growforce Flowfeed products; about 20% used or have recently switched to using Liquid N; and a minority of producers (<10%) used the Virbac Maxiphos supplement. Thirty per cent of producers supplemented their stock all year, including during the wet.

This breakdown of mixes does not reflect the brand of water medication units as about half of the producers interviewed used NORPRIM units but only a small proportion used the Norprim prepared mixes. The NUTRIDOSE unit was the next most popular unit and only a small number of producers were still using DOSATRON units.

## *Advantages and disadvantages of various N, P and S supplements and of home made* v *prepared mixes*

### Supplement components

Producers can source stockfeed grade fertilisers, or technical or food grade products from various suppliers ensuring the cheapest source (Table 6). Technical grade refers to the solubility of the fertiliser and the size of the granules. In some fertiliser products, technical grade and fertiliser grade differ slightly in formulation. Some technical grade products have a better production QA process and have lower levels of heavy metals such as cadmium or fluoride. Due to the high content of fluoride some granular P fertiliser products are specifically labelled 'for fertiliser use only'. These include fertiliser grade monoammonium phosphate (MAP) and diammonium phosphate (DAP).

As can be seen in Table 6, fertiliser grade products can be 30 to 50% cheaper than technical grade products but this can be deceptive, as due to their poor solubility they may not deliver the right amounts of nutrients unless delivery rates are increased substantially. Due to increased inputs for mixing and cleaning of nutrient tanks and the possibility of damage to the dispenser, the increased labour and other costs may outweigh initially lower purchase prices of supplements.

Table 6 Supplement component and home mix costs for home mixes used in different localities and seasons (June 2004)

| Product | Urea % | **N %** | CPE % | S % | P % | Trace Elements | Cost $/tonne (Incl GST) delivered Roma | Cost c/head/day 60g urea, dry season |
|---|---|---|---|---|---|---|---|---|
| Fertilizers – ingredients for home mixes | | | | | | | | |
| **Urea** | | 46 | 287 | | | | 528 – 550 | |
| SOA (Incitec Gran-Am; tech grade) | | 20 - 21 | 126 | 24 | | | 380 Gran-Am 580 Tech grade SOA | |
| **Incitec Stockfeed Sulphur** | | | | 98.8 | | | 784 | |
| Magnum P44 (urea phosphate) | | 18 | | | 19.2 | | 1280 | |
| Tech grade MAP (Incitec Liquifert P) | | 12 | 75 | | 26.6 | | 1100 – 1400 | |
| Monosodium phosphate (MSP) | | | | | 26 | | 1500 | |
| Fertilizer grade MAP | | 10 | 62.5 | | 21 | | 600 | |
| Home mixes | | | | | | | | |
| 70% urea, 10% tech grade SOA, 20% MAP | 70 | 36.6 | 229 | 2.4 | 5.2 | No | 528 | 4 |
| 80% urea, 20% SOA | 80 | 40.8 | 255 | 4.8 | 0 | No | 540 | 4 |
| Keith Hill (NT) mix: 55% urea, 23% MAP, 23% SOA | 55 | 32.9 | 206 | 5.5 | 6 | No | 512 | 6 |

Quotes sourced from Miscamble Bros Hardware & Rural Supplies (Neil Innes CRT); Primac Elders and Landmark (all in Roma).

There are various forms of **urea**, for example Incitec has four grades of urea. Granulated urea is hard and has large particle sizes, which makes it poorly soluble and difficult to mix. Stockfeed Urea or Liquifert N is obtained by screening under-sized granules from granulated Urea. This product is easier to dissolve than granulated urea because of smaller particle size. Prilled Urea is imported into Mackay, is softer and has a slightly smaller particle size than Stockfeed Urea. It dissolves more quickly than the granulated grades. Ideal urea formulations should also contain <1% biuret, which is a non-soluble condensation product of urea. High biuret urea (3%) leaves more residues in the nutrient tank and delivery system.

The most suitable **P**sources for water medication in neutral water are technical grade MAP and food grade monosodium phosphate (MSP). Technical grade MAP is acidic in solution; has no buffering capacity; and is cheap (currently being imported from China). Food grade MSP is a highly soluble, excellent quality source of P. A less recommended alternative is technical grade diammonium phosphate (DAP), however this is neutral to alkaline in water; increases urea volatilisation; and is no cheaper than technical grade MAP.

Other P products include urea phosphate for use in alkaline water, and phosphoric acid (Class 8 Dangerous Goods code; corrosive, dry solid) that can reduce water intake and now is rarely used. Kynofos and dicalcium phosphate (DCP) are both non-soluble forms of P and should only be used in dry licks.

P supplements should not be mixed with calcium salts, magnesium salts, or metallic sulphates, as insoluble precipitates will form. Calcium is insoluble so supplements containing calcium cannot be put through a water dispenser.

Supplementary sources of **S**include sulphate of ammonia (SOA, Gran-Am), sodium sulphate, and flowers of sulphur (elemental sulphur). Incitec has only one SOA source suitable as a stockfeed, Gran-Am. Gran-Am, however, does contain granulation and coating agents, that may cause sediments to form in mixing tanks, particularly if water is alkaline or hard, or if P supplements are also used in the mix. A scum may also form on the solution, or be left on the internal walls of the mixing tank. If the sediment or scum causes problems, it may be necessary to purchase a higher-grade ammonium sulphate product from a supplier other than Incitec.

Elemental sulphur is not very soluble and whilst small particle size sulphur (e.g. Incitec Stockfeed Sulphur) can be utilised in dry licks it is less suitable for use in water medicators.

## Home Mixes

The obvious advantage of homemade mixes is cost (Table 6). They are the cheapest to feed at about 4c/head/day. Producers can source stockfeed grade fertilisers, or where appropriate (Section 2), technical or food grade products from various suppliers to develop supplement mixes. ‘Home mixes’ can also be modified as the season changes and available nutrition decreases. They can be custom made for a particular property or a particular livestock type, however this requires a knowledge of nutrition, pasture quality and objective measurements of animal performance.

## Prepared mixes

Prepared mixes are usually designed on the ‘one shot fits all’ principle, unless specific property needs have been identified. Specific mixes are then prepared to fit particular requirements e.g. changing seasonal conditions or different water qualities. Specific mixes are also often more expensive than large batch prepared mixes. The most frequently cited advantage of prepared mixes is safety, simplicity and reduced time involved in mixing. Many producers not directly involved with the day to day operations of their water medication would rather the process be simplified to reduce or eliminate any possibilities of human error causing cattle losses. For minimally trained staff it is easier to remember ‘X’ number of bags of supplement per concentrate tank than proportions of three different components that need to be added to the water.

As can be seen in Tables 7 and 8, there are varying sources of prepared mixes containing a range of proportions of N, S, P, and trace elements, and designed for either dry or wet season feeding. With independent nutritional advice, any of these prepared mixes would be suitable for most operations in northern Australia.

Table 7. Dry Season proprietary mixes available for adding directly into nutrient tanks (Costs June 2004).

| Product | Urea % | N % | CPE % | S % | P % | Trace Elements | Cost $/tonne Incl GST, delivered Roma | Cost c/head/day 60g urea dry season; 30g urea, 10g P wet season?? |
|---|---|---|---|---|---|---|---|---|
| Dry Season Supplements | | | | | | | | |
| Norprim Dry feed. Acid base, alkaline waters | 72.7 | 32 | 200 | 4.7 | 3.6 | Yes | 1100 | 9 |
| PFSA Products (Nutridose) | | | | | | | | |
| PFS 2 alkaline waters | 71 | 32.7 | 204 | 2.4 | 8 | No | 1335 | 11 |
| PFS 3 NT Keith Hill | 70.5 | 32.4 | 203 | 5.4 | 6 | No | 1155 | 9 |
| PFS 4 NT dry season; alkaline waters | 85.9 | 39.5 | 247 | 3.7 | 2 | No | 1159 | 8 |
| PFS 5 dry season | 94.5 | 43.5 | 272 | 2.4 | 0 | No | 1106 | 7 |
| Growforce Flowfeed (GF) products | | | | | | | | |
| GF Formula 1 | 93.9 | 43.2 | 270 | 2.4 | 0 | Yes | 924 | 6 |
| GF Formula 2 alkaline waters | 86.3 | 39.7 | 248 | 3.1 | 2 | No | 946 | 6 |
| GF Formula 3 alkaline waters & higher P | 80.8 | 37.2 | 232 | 2.8 | 4 | No | 990 | 7 |
| Cattle King Liquid N | | | | | | | 612 / 200L | 12 / 40ml |

The disadvantages of prepared mixes are the lack of capacity to adjust nutrient levels for varying conditions and the cost of these products. However cost factors need to be balanced against the cost savings from reduced labour inputs and reduced mortality risks. Some producers have reported that by ordering large quantities, costs were only marginally higher than the costs of home-mix ingredients. There have also been complaints from some producers that some prepared mixes leave residues in the concentrate tank, and these problems should be relayed to the manufacturer.

## Liquid supplements - Cattle King Liquid N

Since the latter part of the 2003 winter, the number of producers using CattleKing Liquid N supplement through water medication has been increasing rapidly. Ten to twenty per cent of producers interviewed were using or had used Liquid N. The product has only been in use for a relatively short period of time and while there are no objective production responses available, most producers interviewed claimed to be generally happy with cattle responses to this product.

Liquid N is claimed to be a slow release source of ammonia consisting of 32% carboxyl-amide polymer and 2% lignosulphonate. Lignosulphonate is a chelating or binding agent and a by-product of the paper pulp industry. The composition of the remaining components of the product is not listed on the label but the company has stated that it is 12-16% other trace elements and 50% water.

Producers need to be aware that other previously developed products that have claimed to be slow release sources of NPN have not been effective for two reasons. Firstly, the release is not slow enough, as these products have generally released ammonia over a six hour period. The definition of a slow release source of NPN is that it must not only be a safer product, but also must release ammonia over a minimum of 12 hours (P Dew, Integrated Animal Production, pers comm).

Secondly, the nitrogen might be so tightly bound that it does not allow all of the NPN to be converted to ammonia. This can happen with products bound to lignosulphonates. Many of these slow release products also need an ‘adaptation phase’, which may be between 12 and 24 days to allow rumen micro-organisms to develop processes for breaking down tightly held NPN compounds.

The sound principle behind CattleKing Liquid N supplement is the development of a safer and more consistent product for supplying N through water medication. However unlike the situation with urea supplements, where we have evidence and experience of generally positive responses over many years, at the moment there is no good objective independent evidence of positive responses to Liquid N.

Until such time as this product has been independently assessed and claims verified, producers need to be cautious in accepting some of the advantages claimed for the product. In particular, claims that need verification and that have currently had some anecdotal questioning by users, include the extreme safety of the product, the organic certification and product stability in hard and alkaline waters. According to Biological Farmers of Australia (BFA), CattleKing Liquid N is not currently a certified organic product but it is in the process of re-formulation to re-achieve organic certification.

## Trace element mixes

Animals will only respond to trace elements if the primary deficiency, usually protein, energy or P, has been satisfied; if there is a critical deficiency of a particular trace element in soils in an area; or in times of stress when the immune system is being compromised, for example weaning, pre-calving, transport. It is important to be sure, by appropriate testing, that a trace element deficiency exists, and in most situations not to expect any miraculous results by supplying trace elements.

Some prepared supplements such as Norprim dry season and Growforce Flowfeed 1 & 4 products contain trace elements. Some producers add individual trace elements separately, the most commonly used being copper, zinc, selenium, magnesium (grass tetany) and cobalt. However there is always a risk of toxicity (e.g. copper and selenium) if individual elements are added in incorrect amounts. Table 8 summarises information on other mixes and supplements used through water medication.

Table 8. Wet season proprietary mixes and other supplements used through water medicators

| Product | Urea<br><br>% | N% | CPE<br><br>% | S % | P % | Trace Elements | Cost<br><br>$/tonne Incl GST<br><br>delivered Roma | Cost<br><br>c/head/day<br><br>60g urea dry season;<br><br>30g urea, 10g P wet season |
|---|---|---|---|---|---|---|---|---|
| Wet season supplements | | | | | | | | |
| Norprim Green feed | 37.5 | 41.9 | 262 | 2.5 | 13 | Yes | 1677 | 8 |
| Growforce Flowfeed<br><br>GF Formula 4 Alkaline waters; wet season (30g urea & 18g P) | 35 | 16.1 | 101 | 2.4 | 21.2 | Yes | 1328 | 11 |
| Maxiphos – chelated minerals | | | | | 16.2 | | 1012 / 200L | 31 |
| Trace element supplements | | | | | | | | |
| | Co | Cu | Zn | S | P | Ca | | |
| Virbac<br><br>Maxi-Min | 0.1 % | 0.6 % | 0.8 % | 4.2 % | 0.3 % | 0.2 % | $312 / 20L<br><br>ex Brisbane | 3 |
| Others: Bo, Fe, Mg, Mn, Na, Se. Recommended rate: 2ml daily for maintenance or 1ml/10kg in a deficiency or stress situation. | | | | | | | | |
| Natrakelp Liquid Seaweed | 12ppm<br><br>neg | 6ppm<br><br>neg | 30ppm<br><br>neg | 0.82 % | 0.15 % | 1.4 % | $72/ 20L<br><br>ex Brisbane | 1 |
| Others: Bo, Fe, Mg, Mn, Na, Se, I, K. Recommended rate 1 ml daily | | | | | | | | |

The most commonly used trace element supplements are Virbac Maxi-Min and NatraKelp Liquid Seaweed. A number of companies use a lignosulponate based chelation process in the formulation of their trace element mixes. These chelated trace elements form cross links with amino acids and peptides in the rumen, allowing them to largely bypass the rumen and undergo enzymatic digestion and absorption in the abomasum and small intestine. This leads to higher levels of trace elements being stored and utilised. However according to Jay Branam, nutritionist with Nutrition Service Associates, Brisbane, the usefulness of chelated *v* inorganic minerals is dependent on several variables. For most pasture situations, considering the cost of chelated minerals, inorganic minerals may be appropriate.

Natrakelp Liquid Seaweed conforms to organic standards set out by Biological Farmers of Australia (BFA) and this may be attractive to organic producers. Apart from iodine, iron and potassium, which are not usually deficient in northern Australia, the levels of trace elements in Liquid Seaweed are too low to be of significant benefit in most situations. There have been no objective trials on the product, but some of the subjective claims of positive responses to Liquid Seaweed may be due to components other than trace elements in the product.

## Other products used through water medicators

Other products that have been used in the water include anti-bloat treatments, antibiotics, anthelmintics, amino acids including methionine, and most commonly in northern Australia, electrolyte and sugar supplements. It is debatable whether amino acids used in water medication will have much benefit, as only 15 – 20% of water bypasses the rumen (S. McLennan, pers comm.) and most amino acids will be largely degraded in the rumen. Amino acids such as methionine may thus become an expensive source of S and/or N.

A number of producers in northern Australia are using water medication to supplement weaners with electrolytes and trace elements in order to reduce stress and improve immunity. Dr Lee Taylor (DPI&F, Biloela) does not believe this form of water supplementation will have a positive effect unless many other management issues are addressed. These include dust reduction, the use of hay racks to reduce faecal contamination, the provision of adequate trough space for feeding, handling manageable group sizes that reduce stress and not mixing weaners with those weaned earlier. This avoids major weight and experience differences which could lead to competition and disease problems.

Other producers are supplementing stock prior to transport. It is claimed that provision of electrolytes and sugars through water medicators reduces stress levels and improves meat quality. However recent work in North Queensland has suggested that consistent positive responses to electrolytes cannot be achieved (L. Fitzpatrick, pers comm). Another application is the use of a water flavouring product eg Stoc-Joy®(See Section 4) to enhance the uptake of electrolytes and to improve water consumption. However, price and practicalities may preclude use of this product in paddock situations.

## Which mix to use?

The selection of an appropriate water supplement will depend on seasonal conditions, pasture quality, class of cattle being supplemented, production objectives, water quality status (particularly pH), staffing issues and, whether mineral deficiencies, particularly P are known to be a problem.

Some rules of thumb are:

- analysis of water, and establishing water intakes should be carried out prior to adding any supplements.
- when faecal N levels fall below 1.3% or faecal CP is <6%, a primary protein deficiency is indicated, and unless some loss of body condition can be tolerated, supplementation with urea or alternative NPN sources should commence. Many producers use faecal consistency as an indicator of the need to commence NPN supplementation (See Section 2).
- recommended rates of urea feeding vary between 30 and 60g depending on seasonal conditions, pasture quality, type and weight of cattle, production objectives and tolerance of risk. Responses to different supplementation rates will vary considerably within and between properties and seasons.
- producers feeding large numbers of cattle off a single bore with a medicator unit, may wish to use supplements with higher levels of urea to reduce the amount that needs to be mixed in the nutrient tank and to reduce the delivery levels.
- urea will dissolve in its own weight of water. Urea however causes the temperature of the solution to fall as it dissolves, and it becomes increasingly difficult to dissolve as the concentration rises. A practical solubility limit for urea is 25 kg/100 L (25 % w/v) and for technical grade MAP it is 20 kg/100 L.

- SOA and all P supplements except MSP contain various concentrations of N and these products will contribute to NPN levels which may enable a reduction in urea usage.
- urea solutions are alkaline and this may exacerbate some water problems and may affect solubility of other products in the mix.
- most producers in P deficient country are aware that if faecal P levels are <0.35% (depending on N levels) then P is either marginally or acutely deficient.
- in P deficient areas, recommended daily P supplementation rates through the wet season are 5 g/head for dry cattle and 10 g/head for lactating breeders. The lower rate is suitable for lactating breeders in the dry season.
- if the property is P deficient and water is strongly alkaline (pH>7.2) urea phosphate (Magnum P44) may be the P supplement and acid of choice. If the property is not P deficient and water pH is alkaline, HCl may be required.
- nitrogen and sulphur are required in the ratio of approximately 10:1 (N:S) and therefore it is essential to use a sulphur source at an appropriate level when feeding NPN.
- mulga, although high in protein, has low digestibility. Mulga also contains tannins which bind with Sulphur and additional S can improve mulga utilisation. This is even more important on sheep enterprises as the production of wool requires higher levels of sulphur containing amino acids.
- maintaining water intake (and hence pasture and supplement intake) is the primary objective. If some supplements are not compatible with the water source, provide them in dry licks or blocks if they are cost beneficial for production. (A lot of producers are actually feeding both supplement forms safely), and keep all **operations simple**. Remember the **KISS Principle** (Keep it Simple Stupid).

## *Cost comparisons with other forms of supplements*

Supplements containing non-protein nitrogen (NPN) vary considerably in the extent to which they supply other nutrients. Thus any price comparisons should account for energy and bypass protein content as well as urea content.

Supplement categories include those supplying:

- NPN and minerals, with molasses and salt as attractants only and not as an energy source. These include most urea based loose mixes and blocks, and some water medication supplements.

- NPN with the inclusion of molasses or other energy sources. These include M8U and M3U, most pelleted feeds and any loose mixes that include grain.
- a significant percentage of bypass protein. These include loose mixes or pellets containing high levels (>30%) of bypass proteins such as cottonseed, cottonseed meal, copra meal, palm kernel extract, and
- diluted molasses, a protected NPN source and an acid intake control; eg commercial liquid NPN supplements such as Anipro and Prolix. These products are not a primary energy source, and the molasses acts only as a carrier for NPN. The cost of these and other classes of supplements should be compared to that of licks and blocks in the first category above.

Table 9 below shows cost comparisons of supplements based on urea content. All these products, other than M8U, can be legitimately compared based on a consistent urea content. M8U also supplies a significant amount of energy.

***Table 9. Comparative costs of urea in different forms of supplements***

| Product | Urea % | CPE % | Cost/ tonne $ | Recomm. Rate g/hd/day | g urea in Recomm rate | Actual Rate required to deliver 60g urea | c/head/d to deliver 60g urea |
|---|---|---|---|---|---|---|---|
| Proprietary medication mixes | 72 | 201 | 970 | 55 | 40 | 83 | 8 |
| Loose mixes* | 30 | 86 | 550 | 150 | 45 | 200 | 11 |
| Blocks* | 30 | 86 | 1,200 | 70 | 21 | 200 | 24 |
| Commercial NPN supplement | 4.7 to 11.6 | 14 to 33 | 500 | 1000 | 50 | 1200 | 20 to 50 |
| M8U | 8 | 23 | 220 | 500 | 40 | 750 | 17 |

*Note that content and cost of these can vary considerably

The above information shows that water medication is the cheapest method of delivering a daily dose of 60g urea. It is important to know that these costs only involve purchase of supplements, and there is no costing of labour, vehicle maintenance, equipment depreciation, or possible mortalities. There are also no cost benefit comparisons of production responses relative to costs, since good data is difficult to find.

A number of analyses have shown that changes in gross margin (GM) of the breeder herd, due to strategic supplementation to achieve increases in breeder body condition at the end of the dry season, are highly dependent on supplementation costs. In an analysis done in 1998 using the DPI BREEDCOW model, the estimated cost to increase breeder body condition by one unit (from backward store to store) in order to improve fertility ranged from **$7** for efficient **water medication** to **$15** for **dry licks** and to **$30** for **commercial lick blocks**.

When urea-based supplements reduced breeder mortality, they were highly cost effective with, for example, increases in GM of up to $11/adult equivalent (AE). Where the only benefit valued was fertility (increased number of calves weaned), and supplementation was assumed to cost $15/breeder/annum, the increases in GM from additional cattle sales were generally small ($-5 to $+2 /AE). However where supplementation costs could be reduced, for example using water medication technology, the benefits of dry season urea supplementation strategies on weaning rates were highly cost-effective.

The importance of increases in weight at weaning at the end of the wet season and growth rate in the early life of the animal will depend on the age of turnoff and the target market. With younger turn-off ages (store, export, feedlot finishing) now commonly seen in breeding properties in northern Australia, producers receive a higher return for young heavy cattle and the benefits of nutritional supplementation and early tighter conception patterns become more cost beneficial compared to the situation in earlier years when older bullock turn-off was the norm. Most nutrition trials were completed in earlier years.

## *Responses of grazing animals in northern Australia to NPN, S and P supplements*

Responses of grazing cattle to N and P supplements are well documented and mostly well understood (McCosker and Winks 1990, Winks 1990, Ternouth 1990, Miller et al 1997, Dixon 1998). One area that is still hotly debated is production responses to urea during the wet season. Most trials have shown no cost benefit responses and most nutritionists strongly argue that, due to the protein content and digestibility of the grasses, there is no logical reason why there would be a response to urea during the wet season. However, there are many producers who continue to supplement with urea during the wet season.

It is possible however that the responses claimed occur only during the transitional period from wet to dry season conditions when protein and digestibility levels are starting to decline. This is particularly relevant on Mitchell grass pastures where responses to urea of 30 kg in young steers have been found. However experience suggests it is unlikely that similar responses will be seen on northern spear grass pastures during the same period. In southern areas of Queensland, the period of response (dry season) is too short to show a cost benefit to urea supplement. The length of the dry season is a vital factor as to whether there is an economic response to urea supplementation (D Poppi, S McLennan pers comm.).

A number of field studies have indicated positive responses to water based supplements in cattle under a range of environmental conditions. In a study in the spear grass region of north Queensland, McLennan *et al* (1991) reported that during the dry season, weaner heifers responded to urea and SOA provided in drinking water, although a better response occurred when these supplements were fed as a urea/molasses mixture in open troughs. These differences were most likely due to the fact that urea intakes were higher in the urea/molasses group, though additional energy and minerals from molasses would have also been contributing factors.

In another study, Bawden (1997, 1998), reported the results of a three year Producer Demonstration Site observation in the 'desert' country of central Queensland where cow fertility, cow weights and weaning weights were compared in cattle offered supplements either as a dry lick or through a water medicator. During the dry season both urea and P intakes were higher in cattle on medicated water than on dry licks (urea, 22g *v* 15 g; P, 7.7g *v* 3.5g), with similar trends in intake during the wet season (urea, 18g *v* 8g; P, 11g *v* 8g).

Pregnancy rates were 15% higher in breeders on medicated water than on dry licks (77% *v* 62%) although there were only small differences (15kg) in breeder weights. Average weaning weights were slightly but not significantly greater (190kg *v* 182kg) in weaners from cows on water medication.

The production responses reflect the differences in urea and P intakes from using these two strategies, which could be due in part to lower individual variation in nutrient intakes through water medication. This report highlights the fact that variations in intake of licks and blocks may, as mentioned earlier, lead to lower production responses from that type of supplementation strategy.

Urea based supplements provided through dry lick, blocks or water medication will give responses when strategically fed to breeders in northern Australia (Dixon 1998). During severe dry season conditions urea-based supplements reduced liveweight loss by 6 to 10%. This reduced weight loss increased pregnancy rates by 8 to 14%. In contrast where there was sufficient storm rain to provide at least a 'green pick' during the winter and spring, there were no responses to urea-based supplements. In another trial reported by Dixon (1998), improved nutrition of the breeder by feeding urea supplements during the dry season resulted in cows becoming pregnant earlier in the mating season. For example the pregnancy rate in January was improved by 18% and in March by 21%.

At a Producer Demonstration Site in central Australia, lactating cows in Phase 1 of the study were either provided with supplements (N+P+S) through a water medicator or received no supplement (Hill 2002, 2003). At the end of the first phase, supplemented cows were significantly heavier than control cows (446kg *v* 409kg), were in better body condition and had slightly higher pregnancy rates (53% *v* 42%). While average weaning weights were not different, total weaner weight was higher in the treatment group due to the higher fertility of this group.

In phase 2, where heifers were allocated to either water medication or control groups. Though there were no differences in heifer weights, pregnancy rates were 21% higher in the water medication group and in the lactating heifers pregnancy rates were 30% higher (54% *v* 24%). Average weaning weights were similar, but again total weight weaned was higher in the water-medicated group. In phases 1 and 2 of this study, cost/benefit analyses indicated positive responses were achieved and suggested a benefit/cost ratio of about 9:1 or $213/lactating breeder/cow year.

At another Producer Demonstration Site run between 1990 and 1993 in central Australia (Dixon 1998), 400 mixed cattle were separated to use 2 bores, one medicated with urea, MAP and SOA, and the other bore not medicated. The average intake of the supplement over the 2 years was very low at 14g/hd/day. The area around the control bore received more rain over the allocated period. The final production figures did not differ greatly between the two groups although the supplemented cows were heavier and had a lower percentage of non-lactating, non-pregnant cows.

In a recent study on the Mitchell grass associations of the Barkly Tablelands in the Northern Territory, Dr Steve Petty (unpublished) recorded live weight gain advantages over unsupplemented controls of 0.3kg/d in the early dry season and 0.1kg/d over the duration of the dry season, in weaners provided with supplements through water medication.

In a north Queensland trial (Dixon 1998), hay intake in 190kg Bos indicus X heifers increased in proportion to increasing amounts of supplementary urea (provided through dry lick) and was increased by 20% at the highest level of urea supplementation (64g/d). In the Wandoan district, Paul Erbacher and a number of other producers experienced similar results with weaner steers grazing buffel grass pastures. Prior to using urea supplementation through water medication, steers either stagnated or lost weight over the winter. In the four subsequent winters when urea supplementation was used, similar steers gained weight.

A possible explanation for these gains in intake and production is that in smaller paddocks cattle may drink more frequently, with *intakes* of regular smaller spikes of urea that can be more efficiently utilised by rumen microbes. In contrast, in more extensive areas, cattle may only have one large drink daily resulting in a large spike of ammonia in the rumen within 60 minutes, and this cannot be effectively utilised by rumen microbes. Other work has shown that the best response to urea supplements is when urea is fed in small doses on an hourly basis (P. Dew pers comm).

Nitrogen, P and S supplements were fed via the water over a three year period to two groups of steers grazing a predominantly mulga diet in south west Queensland (Clarke 1991). At slaughter, supplemented steers had a 15kg carcass weight advantage and had 2mm more rump fat than unsupplemented steers. Most of the increased gains in supplemented steers were achieved in the first 2 years.

In summary, the variation in response to water medication will be similar to that seen in supplementation by traditional methods. This is not so much due to the method of delivery as to varying nutritional deficiencies which dictate nutritional responses according to season and area.  As with all supplement delivery methods, intake has a significant bearing on the result. Each property, and even paddocks within properties, will show slightly different response to supplements and these should be analysed on a cost benefit basis. The decision on where and when to supplement should be based on this analysis.

# SECTION 7.  SOME DO'S AND DON'TS OF WATER MEDICATION

New users need to think about a range of operational issues when deciding whether to use water medication.  Some of these have been briefly mentioned previously, but the following list pulls most of these issues together.

## *Points to consider:*

- importance of determining water quality.
- consideration of different options to improving water quality.
- recognition of potential interactions between supplement components and water quality components.
- monitoring procedures for water quality and medicated water supplies, e.g. flow meters,  pH meters,  N test kits.
- recording water intakes for at least two distinct seasons before commencing medication.  Continue to record water intake after medication has commenced. This will ensure that medication is not affecting water intakes and will also allow the producer to predict changes in water consumption and adjust medicator  dispensing rates accordingly.
- selection of correct grades (technical not fertiliser), types and combinations of supplements to minimise acceptability/intake problems and precipitation/sedimentation/organic growth problems.
- use of sealable light coloured squat polythene concentrate tanks to minimise evaporation,  inhibit algal growth and reduce water temperature.

- selection of appropriate sized concentrate tanks that contain enough supplement concentrate solution to supply the average mob for a maximum of 7 to 10 days, ensuring fast turn-over of concentrate mix.
- importance of thorough and regular mixing of concentrate solution using effective mixing devices such as fire-fighter pumps.
- selection of appropriate types and sizes of medicators, ensuring adequate power supplies and consideration of built-in safety features.
- location and protection of medicator units, power supplies and cabling.
- use of appropriate types of pipe fittings and installation techniques to minimise corrosion of pipelines and dispensing equipment.
- regular maintenance of units and filters, meters and other monitoring equipment and checking dispensing rates.
- thorough understanding of operations and calibration of units.
- accurate calculations for formulating concentrate mixes and calculation and calibration of volumes of nutrient solution required to be injected into the line to supply required levels of nutrients to the animal.
- ensuring that where possible medicated water is the only water source in a paddock to minimise risks of urea toxicity.
- minimising chances of human error by appropriate and ongoing staff training and supervision.
- monitoring production responses and doing cost benefit analyses, and
- when feeding dry licks or blocks containing urea concurrently, locate these away from the medicated water source. Take very careful note of daily urea consumption patterns, that should not exceed 80g for lactating cows and preferably be in the 40 to 60g range.

## Common problems with medicators

The following list of problems encountered with medicators has been developed from discussions with a very large number of users in cattle areas across northern Australia. The problems are not specific to any particular brand of medicator, nor can the list cover all possible difficulties that have been found.

- damage to rubber pump diaphragms as a result of crystallisation of solids when concentrates are allowed to stand in pump line when not in use

(Solutions: regular purging with fresh water during season; regular unit maintenance; flush pumps with fresh water after season; renew diaphragms as required).

- blockage/malfunction of water flow sensors and pumps with organic matter, concentrate precipitates and sludges or scale, resulting in pump malfunctions

(Solutions: in-line filters: regular mixing of concentrate tanks; improvements in water quality; water acidification to remove scale).

- failure of safety devices such as solenoid switches allowing continued injection of supplement concentrate into trough line

(Solutions: regular unit maintenance; regular and frequent monitoring of operations).

- excessive wear on moving pistons and cylinders of water powered proportional medicators as a result of water impurities, resulting in incorrect dosages

(Solutions: replace plastic pistons and cylinders with stainless steel units; in-line filters to remove impurities).

- failure of anti-siphon devices, allowing siphoning of concentrate from tank to trough

(Solutions: correct installations; check functioning; regular and frequent monitoring of operations).

- electronic failures due to power failures or lightning strike

(Solutions: regular battery and solar panel checks; lightning arrestors).

- electronic failures due to wiring/cable damage from chewing by birds and dingoes

(Solutions: protective shielding on cables and units eg wire mesh cage).

- electronic failures due to exposure to ammonia fumes and/or concentrate solution contamination

(Solutions: correct water quality problems to minimise ammonia fumes; avoid removing any protective/waterproof covers on units; mount units in vertical position; have clean hands when adjusting settings).

- incorrect setting on units to either under or over-deliver supplement concentrate, often due to lack of information on water intakes

(Solutions: routine recording and logging of water intake data with medicator adjustments as needed), and

- adjustments and modifications to medicators by staff unfamiliar with operations, sometimes leading to medicator malfunctions or delivery of incorrect doses

(Solutions: staff training and instructions; regular monitoring by principal operator).

# SECTION 9. CONCLUSIONS

The basic principles behind the strategic use of nutritional supplements for beef cattle have now been well established and are accepted by most producers. Further, the benefits of supplementation, particularly with protein and phosphorus, have been extensively researched, are now clearly recognised and, consequently are routine management practices throughout much of the northern Australian beef industry.

However, one of the main problems incurred with traditional supplementation using dry licks and blocks has been the variable and erratic intake of supplements between animals.

The basic philosophy behind supplying critical limiting nutrients through water medication is sound, as supplement intake is directly related to water intake. Water medication is now being used successfully by many commercial producers, but the technology is in a relatively early phase of development, and success depends upon a number of factors:

**Control of water supplies**. Water medication will have limited application in situations where uncontrolled surface waters are the major water source for cattle.

**Water quality issues**, which were the major factor identified by a large number of producers. These issues are important not only for medicator use, but also because suitability of water (defined as water intake levels that will optimise productivity) has a major impact on cattle productivity. Much wasted time and effort could be avoided if there was a better understanding of impacts of water quality on productivity and on the efficiency and ease with which supplements can be provided.

**Understanding how, where and why adverse reactions occur between N and P supplements and some components in poor quality water.** This knowledge is necessary for developing solutions for modifying water quality, and so that better supplement components can be used or developed.

**Developing better water modification strategies** than presently available. While some modification techniques such as magnets have reasonably good track records, they have proved ineffective in some situations. Too often modification strategies have been a ‘suck it and see’ approach which can be costly when things do not work. Alternative strategies and techniques, some of which have been used in industrial and domestic water treatment applications, need to be tested for their practicality and cost.

**Competent expertise in management and monitoring** of equipment, and mixing of nutrients. Water medication has been, and will only be successful in the hands of those producers prepared to understand and commit to water medication. The strategy is also not without some risks of cattle deaths due to urea toxicity, though these can be minimised, for example in low input situations, by selection of proprietary mixes and use of lower intake levels.

**Having good information on seasonal variations in nutritional status, and on water intakes** over a period of at least two seasonal changes, before commencing water medication. This will assist with selection of appropriate supplement rates for expected levels of water intakes and will optimise production responses.

**Preparedness to vary water medication levels** according to changes in seasonal conditions, and status of stock being supplemented.

**Routine equipment maintenance and replacement of component parts** is essential. Users need to maintain good communications with manufacturers and suppliers of equipment, and independent variations and modifications to equipment or supplement formulations should be avoided as these can prove to be disastrous.

Vigilance is the key to success with water medication.

There are a number of new developments in the pipeline:

- equipment manufacturers are putting in place a range of technological improvements to their equipment to enhance reliability and safety.
- advances in remote sensing technology, and incorporation of sensing devices in medicators is likely to further enhance safety aspects. Remote sensing will be able to provide the capacity for rapid shut down of equipment in the event of component failures, and enable routine monitoring of groundwater supplies and water storage facilities such as tanks and troughs. However it should never be seen as a replacement for routine monitoring of water facilities, pastures and livestock.
- a number of new products are claimed to provide a better source of slow release N and to reduce toxicity hazards, but there is no good objective evidence to support these claims, and
- many proprietary products available for water medication also contain trace elements, but for most (but not all) north Australian situations these are not important limiting nutrients, and their inclusion in supplements is of doubtful value.

Decisions on whether to prepare water medication supplements on-property from readily available components or to purchase proprietary products will be based on a whole range of factors such as comparative costs, labour inputs, convenience, risk factors and availability of quality labour. Regardless of which type of water medication formulation is used, supplement costs are generally lower than other supplementation strategies such as dry licks or blocks.

Many years of research and practical producer experience in northern Australia has given us a good understanding of the benefits of urea and P and of potential hazards with urea. This information and experience has been successfully translated and applied to water medication, but legitimate concerns regarding urea toxicity have constrained many producers from adopting water medication. These can be minimised, but not entirely eliminated, by some of the practices and techniques outlined in this manual.

Water medication has many potential benefits, but there are also some disadvantages. This manual should help producers to make decisions as to whether this form of supplement delivery is suitable for their individual operations. In particular, some of the experiences, tips and traps documented may be of assistance should water medication be the chosen delivery method.

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