URINE CHEMICAL ANALYSIS AND MEDICAL USES: A COMPRHENSIVE REVIEW

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ABSTRACT

Urine is an aqueous solution of waste electrolytes and metabolites excreted by mammals, birds, reptiles, fish and amphibians. Although urine is excreted as a paste (uric acid) by most birds, it is commonly excreted as a fluid varying in color from clear, when dilute, to dark amber, when concentrated. Urine is produced by the kidneys, and plays a vital role in maintaining homeostasis by removing excess water, electrolytes such as sodium, chloride, potassium, and calcium ions, urea and other metabolites from the blood. Urine excreted by healthy kidneys is sterile. The production of urine is called diuresis. Urine is liquid waste product of the body secreted by the kidneys by a process of filtration from blood and excreted through the urethra. This waste is eventually expelled from the body in a process known as urination. Most commonly the excretion of urine serves for flushing waste molecules collected from the blood by the kidneys, and for the homeostasis of the body fluids. The present paper reviews the chemical analysis and medical uses of urine.

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INTRODUCTION

The yellow color of urine was previously thought to come from gold. Alchemists spent much time trying to extract gold from urine, and this led to discoveries such as white phosphorus, which was discovered by the German alchemist Hennig Brand in 1669 when he was distilling fermented urine. In 1773 the French chemist Hilaire Rouelle discovered the organic compound urea by boiling urine dry.

There are also reports surfacing recently that urine contains small amounts of omreormus style monoatomic transition metals (such as ruthenium, osmium, iridium, rhodium, palladium, platinum, gold, silver, copper, cobalt and nickel). Some claim these are found in very small amounts in normal drinking water, vegetables, fruits, meat, and other foods. We consume these inadvertently anytime we eat or drink. These claims have not been confirmed yet, because of the difficult task of analyzing ORME style elements.

COMPOSITION

Urine is the byproduct or fluid secreted by the kidneys, transported by the ureters to the urinary bladder where it is stored until it is voided through the urethra.

It is a transparent solution that is clear to amber in color, and is usually a light yellow color. Urine is made up of a watery solution of metabolic wastes (such as urea), dissolved salts and organic materials. Fluid and materials being filtered by the kidneys, destined to become urine, come from the blood or interstitial fluid.

The composition of urine is adjusted in the process of reabsorption when essential molecules needed by the body, such as glucose, are reabsorbed back into the blood stream via carrier molecules. The remaining fluid contains high concentrations of urea and other excess or potentially toxic substances that will be released from the body via urination. Urine flows through these structures: the kidney, ureter, bladder, and finally the urethra. Urine is produced by a process of filtration, reabsorption, and tubular secretion.

Urine contains large amounts of urea, an excellent source of nitrogen for plants. As such it is a useful accelerator for compost. Urea is much less toxic than ammonia and is formed by the indirect combination of the byproducts of deamination (2 NH_3 molecules) and cellular respiration (1 CO_2 molecule). Other components include various inorganic salts such as sodium chloride (sodium discharge is called natriuresis).

Water

The main constituent of urine is water. All vertebrates must carefully maintain the volume of fluid in their extra-cellular space in order to prevent fluid overload or dehydration. Some water is inevitably lost during solute excretion, and represents an unavoidable fluid loss. However, the majority of water excreted in the urine is lost to prevent fluid overload. Different animals have different renal physiologies depending on their need to retain water. Freshwater fish, for example, produce very large amounts of very dilute urine, whereas desert-dwelling animals such as the meerkat have evolved very effective renal systems, allowing them to conserve water by producing small amounts of extremely concentrated urine. Human kidneys are not that effective - even the most concentrated human urine is relatively dilute. The excretion of water is called aquaresis.

Electrolytes

Along with volume regulation, urine regulates the osmolarity of an animal's internal space. The concentration of ions in the blood and extra-cellular fluid must stay within a fairly tight range to maintain health and avoid dehydration. Although some ions are lost to normal bodily function (such as sweating), most animals have a large surplus of ions in their diets and must excrete them. Most humans, for example, ingest many more sodium and chloride ions than they need in the form of [salt] - it is secretion of these surplus ions, which makes urine taste salty.

Nitrogen

Urine production and excretion is a vertebrate's primary method for removal of nitrogen. This is a waste product, produced in the form of ammonia by the liver. Excess nitrogen is found in the diet, and released into the blood during the deamination of amino acids in protein metabolism. In fish, where water conservation is not an issue, ammonia is excreted in dilute urine. However, at higher concentrations it is toxic, and so in mammals' urine, this mainly is in the form of urea, produced from ammonia in the liver. Birds generally excrete uric acid as a paste, to further conserve water.

Acid

The kidneys play a vital role in regulating body pH, preventing acidosis or alkalosis by excreting excess hydrogen ions or bicarbonate ions as required. When it leaves the body, urine is usually around pH 6, though it may be as low as 4.5 or as high as 8.2. As urea—

the compound which accounts for 75–90% of the nitrogen in urine—begins to decay, hydroxide ions form, raising the pH as high as 9–9.3.

The decay of urea into carbon dioxide is catalyzed by urease:

$$(NH_2)_2CO + H_2O \rightarrow CO_2 + 2NH_3$$

Metabolites

Animals ingest a wide variety of compounds daily. Not least are humans, who consume an incredible array of natural and artificial chemicals in the form of food, drink and pharmaceutical products. With the exception of vitamins, minerals and other micro-nutrients such as essential fatty acids, none of these are needed or desirable within the body. All are either metabolised by the liver, excreted in bile or filtered from the blood by the kidneys, and excreted in urine.

Dissolved heavy metals

Studies of urine in organic cattle farms in Sweden in 1999 and 2002 yielded the following concentrations of heavy metals (all in μg/kg wet weight):

- Copper: 67
- Zinc: 30
- Chromium: 5
- Lead: 1
- Cadmium: 0
- Glucose

Glucose is constantly lost from the blood into the filtrate at the kidneys - however, active reuptake in the proximal tubule usually prevents any being excreted. This is desirable, as glucose is a valuable source of energy, not a waste product. However, in hyperglycaemia - most commonly arising from diabetes mellitus in humans - the tubular limit on glucose reabsorbtion may be breached, in which case some glucose with be lost in the urine.

Bacteria

Urine excreted by healthy kidneys is sterile. When it leaves the body, however, the urine can pick up bacteria from the surrounding skin, which would contaminate it.

CHARACTERISTICS

Colour

The typical bright yellow colour of urine is caused by the pigment urochrome, but also from the degradation products of bilirubin and urobilin. Clear colors are a sign of hydration and are the preferred colors of urine.

Unusual colouration

Yellowing/light Orange may be caused by removal of excess B vitamins from the bloodstream.

Certain medications such as rifampin and pyridium can cause orange urine.

Bloody urine is termed hematuria and is a symptom that requires medical attention. (This could also be a sign of a bladder infection, which also requires medical attention.) Consumption of beets can cause urine to have a pinkish tint; the condition is harmless and temporary.

Dark orange to brown urine can be a symptom of jaundice or Gilbert's syndrome.

Black or dark-colored urine is referred to as melanuria and may be caused by a melanoma.

Reddish or brown urine may be caused by porphyria. Again, the consumption of beets can cause the urine to have a harmless, temporary pink or reddish tint.

Flourescent Yellow / Greenish urine may be caused by taking dietary supplemental vitamins, especially the B vitamins.

Dark yellow urine is usually caused by dehydration.

Turbidity

Turbid urine may be a symptom of a bacterial infection, but can also be due to crystallisation of salts in the urine (e.g. calcium phosphate), which will dissolve if acetic acid (vinegar) is added.

pH

The pH of urine is close to neutral, i.e. 7, but can normally vary between 4.5 and 8. Strongly acidic or alkaline urine may be a symptom of a disease.

Amount

The amount of urine produced depends on numerous factors including state of hydration, activities, environmental factors, size, and health. In adult humans the average production

is about 1 - 2 L per day. Producing too much or too little urine needs medical attention: Polyuria is a condition of excessive production of urine (> 2.5 L/day), in contrast to oliguria where < 400 mL are produced per day, or anuria with a production of < 100 mL per day.

Density or specific gravity

Normal urine density or specific gravity values vary between 1.003-1.035 ($g.cm^{-3}$), and any deviations may or may not be associated with urinary disorders.

FUNCTION

Urination is the primary method for excreting toxins, chemicals and drugs from the body. These chemicals can be detected and analysed by urinalysis. Cellular metabolism results in a buildup of toxic nitrogen compounds, or nitrogenous waste. Since this waste is toxic, most animals have excretory systems (in humans this is known as the Urinary system, which consists of the Kidneys, Urinary bladder, Ureter, and Urethra) to rid themselves of this waste. The kidneys extract the nitrogenous wastes from the bloodstream, as well as excess water, sugars, and a variety of other chemicals.

In cases of kidney or urinary tract infection (UTI), the urine will contain bacteria, but otherwise urine is virtually sterile and nearly odorless when it leaves the body. However, after that, bacteria that contaminate the urine will convert chemicals in the urine into smelly chemicals that are responsible for the distinctive odor of stale urine; in particular, ammonia is produced from urea.

Some diseases alter the quantity and consistency of the urine, (e.g., sugar in the urine is a sign of diabetes).

USES

URINE IN MEDICINE

Examination

Many physicians in history have resorted to the inspection and examination of the urine of their patients. Hippocrates described urine examination. Hermogenes wrote about the color and other attributes of urine as indicators of certain diseases. Abdul Malik Ibn Habib of Andalusia d.862CE, mentions numerous reports of urine examination throughout the Umayyad empire. Diabetes mellitus got its name because the urine is

plentiful and sweet. A urinalysis is a medical examination of the urine and part of routine examinations. A culture of the urine is performed when a urinary tract infection is suspected. A microscopic examination of the urine may be helpful to identify organic or inorganic substrates and help in the diagnosis.

The color and volume of urine can be reliable indicators of hydration level. Clear and copious urine is generally a sign of adequate hydration, dark urine is a sign of dehydration. The exception is when alcohol, caffeine, or other diuretics are consumed, in which case urine can be clear and copious and the person still be dehydrated.

Application

The use of urine therapy as a medical treatment or daily health regimen is uncommon. Aztec physicians used urine to clean external wounds to prevent infection, and administered it as a drink to relieve stomach and intestine problems. Purported beneficiaries of the 'urine cure' include Jim Morrison, and Steve McQueen. Its medicinal properties have also been used in China as a part of holistic medicine, and in India, especially as part of the traditional Indian medicine, Ayurveda, under the name Amaroli.

Resource

Urine may contain proteins or other substances that are useful for medical therapy. Urine from postmenopausal women is rich in gonadotropins that can yield follicle stimulating hormone and luteinizing hormone for fertility therapy. The first such commercial product was Pergonal. Urine from pregnant women contains enough human chorionic gonadotropins for commercial extraction and purification to produce hCG medication. Pregnant mare urine is the source of estrogens, namely Premarin.

In recent times, the Port-A-John corporation of Utica, Michigan, USA has developed a filter to collect medically significant proteins from users of their chemical toilets.

Gardening

Urine has applications in gardening and agriculture as a fertilizer. Gardeners often recommend a dilution of 10-20 parts water to one of urine for application to pot plants and flower beds during the growing season; pure urine can chemically burn the roots of some species. Urine typically contains more than 50% of the nitrogen and phosphorus and potassium content of whole sewage, and is widely considered as good as or better than commercially-available chemical fertilisers or stabilised sludge from sewage plants.

Urine is also used in composting to increase the nitrogen content of the mulch, accelerating the composting process and increasing its final nutrient values.

Food-crop agriculture

Urine is also being actively considered as a fertilizer for use in food-crop agriculture in developed countries. Studies into its feasibility and safety usually indicate that it is an acceptable alternative to chemical fertilisers and stabilised sludge. However, the technology to implement its use on a large scale has not been developed, and is considered too expensive. There are also concerns over its safety regarding the potential for transmitting infectious disease and refluxing xenobiotic compounds (associated with toilet-cleaning products and prescribed drugs expelled in urine) in the human food chain. Proponents of adopting urine for this use usually claim the risks to be negligible or acceptable, and point out that sewage causes more environmental problems when it is treated and disposed of compared with when it is used as a resource. Critics generally agree that more research is needed into how the resource is to be collected, processed and handled.

Crop fertilizing

A few people use urine as a crop fertilizer. These include organic farming cooperatives and eco-villages where special urine-diverting toilets with collecting tanks are installed. Many of these also employ concepts such as greywater irrigation and the composting of fecal matter. Many are the subject of ongoing feasibility studies sanctioned by governments and private organisations. These people generally reject safety concerns over its use on food crops provided that it is used with common sense. For example, application to fruit trees is considered safer than to bushes and especially root crops. It is also considered sensible to cease application at a safe interval before harvesting. However, the use of urine for this purpose is even rarer than its use on ornamental gardens.

In developing countries, the application of pure urine to crops is also rare. However, whole, untreated sewage, termed night soil, is often applied to crops and is considered essential. This practice has been applied, along with crop rotation schemes, for thousands of years. In Japan, urine used to be sold to farmers who process it into fertilizers

Survival uses

Shipwrecked or people otherwise adrift at sea for long periods often resort to drinking their urine when no rainwater is available, seawater being unsuitable. People stranded in deserts often also drank urine to prevent life-threatening dehydration from setting in. However, this desperate measure achieves little to delay death from thirst as urine dehydrates one in the same manner saltwater does.

During World War I, the Germans experimented with numerous poisonous gases for use during war. After the first German chlorine gas attacks, Allied troops were supplied with masks of cotton pads that had been soaked in urine. It was believed that the ammonia in the pad neutralized the chlorine. These pads were held over the face until the soldiers could escape from the poisonous fumes, although it is now known that chlorine gas reacts with urine to produce toxic fumes (see chlorine and Use of poison gas in World War I).

Urine has also been historically used as an antiseptic. In times of war, when other antiseptics were unavailable, urine, the darker the better, was utilized on open wounds as an antibacterial.

Urban myth states that urine works well against jellyfish stings, although in reality it is at best ineffective and in some cases may actually make the injury worse.

Diagnostic tests

Testing urine for its constituents is a cost-effective and non-invasive means of assessing the internal situation of an animal. It is commonly used to test for pregnancy, by measuring levels of hormones excreted. Urinalysis can also be used to test for the metabolites of illegal drugs, if substance abuse is suspected. It is also an invaluable first-line investigation in clinical medicine, where pH, glucose, protein, white blood cell, bacteria and blood content can all be tested to aid in making a diagnosis.

Fertilizer

Urine has been and is used extensively as fertilizer. Its high nitrogen content allows increased amino acid synthesis by plants. During WWII, Japanese farmers used urine collected in so-called "honeypots" as cheap fertilizer for their crops.

Animal repellent

Taking advantage of the scents of male animals' urine, some companies sell animal urine, usually coyote or fox, to cities and other organizations to repel those animals by essentially "marking their territory". The scents of carnivore urine (bobcat, mountain lion, and wolf, in addition to coyote and fox) are also sold to the public in pelletized form to repel garden browsing by herbivores such as squirrels and rabbits, as well as deterring domestic or feral cats from marking territory, or catching birds, in gardens. When the pellets are sprinkled on a target area, the intruding animal will instinctively recognize the territorial urinary scent of its predators and avoid the area.

Munitions

In historical times, urine was collected and used in the manufacture of gunpowder. Stale urine was filtered through a barrel full of straw and allowed to continue to sour for a year or more. After this period of time, water was used to wash the resulting chemical salts from the straw. This slurry was filtered through wood ashes and allowed to dry in the sun. Saltpeter crystals were then collected and added to sulfur and charcoal to create black powder.

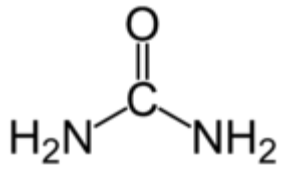
Textiles

Urine has often been used as a mordant to help prepare textiles, especially wool, for dyeing. Urine was used for dyes such as indigo where the urea in the urine reacted with the insoluble dye to form a soluble solution.

Hormone replacement therapy

Steroid hormones extracted from the urine of pregnant mares are used in a drug sold under the trade name Premarin (a neologism derrived from 'pregnant mare urine'). The drug, manufactured and sold by Wyeth, is an estrogen replacement therapy used in the treatment of menopause symptoms.

CHEMICAL ANALYSIS



Here is a list of all substances contained in urine:

1. Non-organic substances in the urine: bicarbonate, chloride, phosphorus, sulphur, bromide, fluoride, iodide, rhodanide, potassium, natron, calcium, magnesium, iron, copper, zinc, cobalt, selenium, arsenium, lead, mercury.
2. Nitrogenous substances in urine nitrogen, urea, creatine, creatinine, guanidine, choline, carnitine, piperidine, spermidine, dopamine, epinephrine, norepinephrine, serotonin, tryptamine, levulinique amino-acid, bilirubin, and so on.
3. Amino acids in the urine: alanine, carnosine, glycine, histidine, leucine, lysine, methionine, phenylalanine, serine, tyrosine, valine, hydroxyloproline, galactosylhydroxylyzine, xylosylserine, and others.
4. Protein in the urine: albumin, haptoglobin, transferrin, immunoglobulins IgG, IgA, IgM, and others.
5. Enzymes in the urine: lactadehydrogenase, gamma-glutamyl transferase, alpha amylase, uropepsinogene, lysozyme, beta-N-acetylglucosaminidase, urokinase, protease, and others.
6. Carbohydrates (sugars) in the urine: arabinose, xyloseribose, fucose, rhammose, ketopentose, glucose, galactose, mannose, fructose, lactose, sucrose, fucosylglucose, raffinose, and others.
7. Substances devoid of nitrogen in the urine: wide assortment of organic acids
8. Vitamins in urine: thiamine (vitamin B1), riboflavin (vitamin B2), vitamin B6, 4-pyridoxique acid, nicotinic acid, vitamin B12, biopterine, ascorbic acid (vitamin C) and others.
9. Hormone in urine: gonadotropin, corticotropin, prolactin, lactogeniques hormones, oxytocin, vasopressin, thyroxine, catecholamines (epinephrine, norepinephrine,

dopamine), insulin, erythropoietin, corticosteroids (aldosterone, corticosterone, cortisone), testosterone, progesterone, estrogen and others.

10. Agglutinines and precipitines: neutralizing action on the polio virus and other viruses.
11. Antineoplaston: selectively prevents the development of cancer cells without affecting healthy cells that
12. Allantoin: nitrogen crystalline substance that promotes healing, from the oxidation of uric acid. It is used in the manufacture of many skin creams.
13. DHEA (dehydroepiandrosterone): steroid secreted by the adrenal glands, present in large quantities in male urine. It prevents obesity, prolongs the life of animals and is a possible treatment against anemia, diabetes and breast cancer. DHEA stimulates the development of the bone marrow and increases its production of red blood cells, monocytes, macrophages and lymphocytes. A low level of DHEA seems to be associated with aging.
14. Antisecretoires gastric: prevent the onset and development of stomach ulcers.
15. Acid glycuronique: produced by the liver, kidneys and intestines, it has a major secretory function.
16. H-11: inhibits the growth of cancer cells and reduces the existing tumors without disrupting the recovery process.
17. H.U.D. HUD (Human’s urine derivative) demonstrates remarkable anticancer properties.
18. Interleukin-1: a positive influence on the auxiliary and inhibitory substances. Can send a signal to the hypothalamus to trigger fever.
19. Trimethyl-glyoxal: destroys cancer cells.
20. Prostaglandine a hormonal substance that dilates the blood vessels, lowers tension, relaxes the muscle walls of the bronchi, stimulates contractions during labor, and many metabolic functions.
21. Proteoglobulines: plasma proteins containing anti-bodies against certain allergens, they are identical to the proteins of immoglobulines blood serum.
22. Prosteoses: immunological products assets allergic reactions.

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