Urine

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Urine is a liquid by-product of metabolism in the bodies of many animals, including humans. It is expelled from the kidneys and flows through the ureters to the urinary bladder, from which it is soon excreted from the body through the urethra during urination.

Cellular metabolism generates numerous by-products, many nitrogenous (rich in nitrogen), that require clearance from the bloodstream. These by-products are eventually expelled from the body during urination, the primary method for excreting water-soluble chemicals from the body. These chemicals can be detected and analyzed by urinalysis. Of the many such substances that exist, the three main nitrogenous wastes of the mammalian body are urea, uric acid, and creatinine.

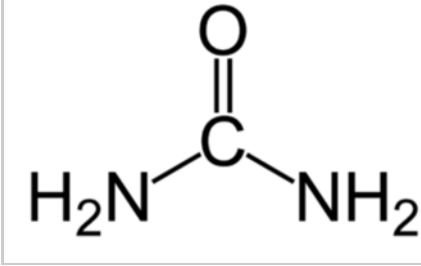
Animal urine forms part of the nitrogen cycle. In balanced ecosystems it fertilizes soil and plants, which in turn continue to support the animal population. Some animals use it to mark their territories. Human urine and human feces are collectively referred to as human waste; as sewage, they require sewage treatment in places where population density is high. Livestock urine and feces similarly require proper management if the livestock population density is high. Such management is part of ecological sanitation.

Contents

Sample of human urine

Physiology

Most animals have excretory systems for elimination of soluble toxic wastes. In humans, soluble wastes are excreted primarily by the urinary system and, to a lesser extent in terms of urea, removed by perspiration.[1] The urinary system consists of the kidneys, ureters, urinary bladder, and urethra. The system produces urine by a process of filtration, reabsorption, and tubular secretion. The kidneys extract the soluble wastes from the bloodstream, as well as excess water, sugars, and a variety of other compounds. The resulting urine contains high concentrations of urea and other substances, including toxins. Urine flows from the kidney through the ureter, bladder, and finally the urethra before passing from the body.



Urea structure

Duration

Research looking at the duration of urination in a range of mammal species found that 9 larger species urinated for 21 ± 13 seconds irrespective of body size.[2] Smaller species including rodents and bats cannot produce jets and instead urinate with a series of drops.[2]

Characteristics

Quantity

Average urine production in adult humans is around 1.4 L of urine per person per day with a normal range of 0.6 to 2.6 L per person per day, produced in around 6 to 8 urinations per day depending on state of hydration, activity level, environmental factors, weight, and the individual's health.[3] Producing too much or too little urine needs medical attention. Polyuria is a condition of excessive production of urine (> 2.5 L/day), oliguria when < 400 mL are produced, and anuria one of < 100 mL per day.

Constituents

About 91-96% of urine consists of water.[3] Urine also contains an assortment of inorganic salts and organic compounds, including proteins, hormones, and a wide range of metabolites, varying by what is introduced into the body.

The total solids in urine are on average 59 g per person per day. Organic matter makes up between 65% and 85% of urine dry solids, with volatile solids comprising 75–85% of total solids. Urea is the largest constituent of the solids, constituting more than 50% of the total. On an elemental level, human urine contains 6.87 g/L

carbon, 8.12 g/L nitrogen, 8.25 g/L oxygen, and 1.51 g/L hydrogen. The exact proportions vary with individuals and with factors such as diet and health.[3] In healthy persons, urine contains very little protein; an excess is suggestive of illness.

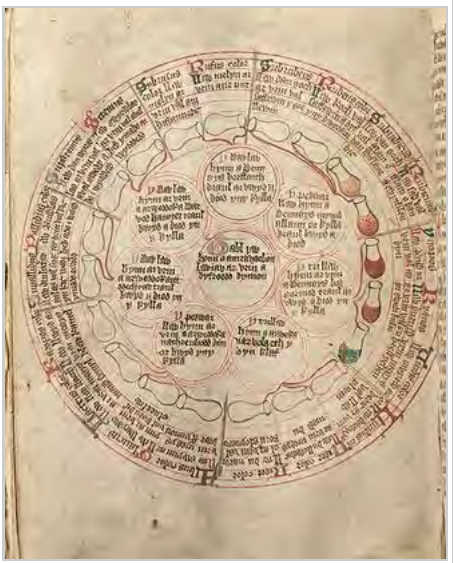
Color

Urine varies in appearance, depending principally upon a body's level of hydration, as well as other factors. Normal urine is a transparent solution ranging from colorless to amber but is usually a pale yellow. In the urine of a healthy individual the color comes primarily from the presence of urobilin. Urobilin is a final waste product resulting from the breakdown of heme from hemoglobin during the destruction of aging blood cells.

Green urine during long term infusion of the sedative propofol

Colorless urine indicates over-hydration, generally preferable to dehydration (though it can remove essential salts from the body). Colorless urine in drug tests can suggest an attempt to avoid detection of illicit drugs in the bloodstream through over-hydration.

- Dark yellow urine is often indicative of dehydration.
- Yellowing/light orange may be caused by removal of excess B vitamins from the bloodstream.
- Certain medications such as rifampin and phenazopyridine can cause orange urine.
- Bloody urine is termed hematuria, a symptom of a wide variety of medical conditions.
- Dark orange to brown urine can be a symptom of jaundice, rhabdomyolysis, or Gilbert's syndrome.
- Black or dark-colored urine is referred to as melanuria and may be caused by a melanoma or non-melanin acute intermittent porphyria.
- Pinkish urine can result from the consumption of beets.
- Greenish urine can result from the consumption of asparagus or foods or beverages with green dyes.
- Reddish or brown urine may be caused by porphyria (not to be confused with the harmless, temporary pink or reddish tint caused by beeturia).
- Blue urine can be caused by the ingestion of methylene blue (e.g., in medications) or foods or beverages with blue dyes.
- Blue urine stains can be caused by blue diaper syndrome.
- Purple urine may be due to purple urine bag syndrome.


Medical experts have long connected urine colour with certain medical conditions. A medieval chart showing the medical implications of different urine color

Odor

The odor of normal human urine can reflect what has been consumed or specific diseases. For example, an individual with diabetes mellitus may present a sweetened urine odor. This can be due to kidney diseases as well, such as kidney stones.

Eating asparagus can cause a strong odor reminiscent of the vegetable caused by the body's breakdown of asparagusic acid.[4] Likewise consumption of saffron, alcohol, coffee, tuna fish, and onion can result in telltale scents. Particularly spicy foods can have a similar effect, as their compounds pass through the kidneys without being fully broken down before exiting the body.[5][6]

Turbidity

Turbid (cloudy) urine may be a symptom of a bacterial infection, but can also be caused by crystallization of salts such as calcium phosphate.

pH

The pH normally is within the range of 5.5 to 7 with an average of 6.2.[3] In persons with hyperuricosuria, acidic urine can contribute to the formation of stones of uric acid in the kidneys, ureters, or bladder.[7] Urine pH can be monitored by a physician[8] or at home.

A diet which is high in protein from meat and dairy, as well as alcohol consumption can reduce urine pH, whilst potassium and organic acids such as from diets high in fruit and vegetables can increase the pH and make it more alkaline.[3] Some drugs also can increase urine pH, including acetazolamide, potassium citrate, and sodium bicarbonate.

Cranberries, popularly thought to decrease the pH of urine, have actually been shown not to acidify urine.[9] Drugs that can decrease urine pH include ammonium chloride, chlorothiazide diuretics, and methenamine mandelate.[10][11]

Density

Human urine has a specific gravity of 1.003–1.035.[3] Any deviations may be associated with urinary disorders.

Hazards

Healthy urine is not toxic.[12] However, it contains compounds eliminated by the body as undesirable, and can be irritating to skin and eyes. After suitable processing it is possible to extract potable water from urine.

Possible pathogens in urine

It is commonly believed that urine is sterile until it reaches the urethra, where epithelial cells lining the urethra are colonized by facultatively anaerobic Gram negative rods and cocci.[13] Current research suggests though that urine is not sterile, even in the bladder.[14] Regardless, subsequent to elimination from the body, urine can acquire strong odors due to bacterial action, and in particular the release of ammonia from the breakdown of urea.

Examination for medical purposes

Many physicians in ancient history resorted to the inspection and examination of the urine of their patients. Hermogenes wrote about the color and other attributes of urine as indicators of certain diseases. Abdul Malik

Ibn Habib of Andalusia d.862 AD, mentions numerous reports of urine examination throughout the Umayyad empire.[15] Diabetes mellitus got its name because the urine is plentiful and sweet. The name *uroscopy* refers to any visual examination of the urine, including microscopy, although it often refers to the aforementioned prescientific or protoscientific forms of urine examination. Clinical urine tests today duly note the gross color, turbidity, and odor of urine but also include urinalysis, which chemically analyzes the urine and quantifies its constituents. A culture of the urine is performed when a urinary tract infection is suspected, as bacteria in the urine are unusual otherwise. A microscopic examination of the urine may be helpful to identify organic or inorganic substrates and help in the diagnosis.

A Doctor Examining Urine. Trophime Bigot.

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 occurs when diuretics or excessive amounts of alcohol or caffeine are consumed, in which case urine can be clear and copious and the person still be dehydrated.

Uses

Source of medications

Urine contains proteins and other substances that are useful for medical therapy and are ingredients in many prescription drugs (e.g., Ureacin, Urecholine, Urowave). Urine from postmenopausal women is rich in gonadotropins that can yield follicle stimulating hormone and luteinizing hormone for fertility therapy.[16] One such commercial product is Pergonal.[17]

Urine of pregnant women in the first trimester is collected by a company who purifies the fertility hormone hCG from it (Ede, the Netherlands)

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.[16] Urine also contains antibodies, which can be used in diagnostic antibody tests for a range of pathogens, including HIV-1.[18]

Agriculture

Urine contains large quantities of nitrogen (mostly as urea), as well as significant quantities of dissolved phosphates and potassium, the main macronutrients required by plants. The exact composition of nutrients in urine varies with diet.

Undiluted urine can chemically burn the roots of some plants which is why it is usually applied diluted with water, which also reduces odour development during application. When diluted with water (at a 1:5 ratio for container-grown annual crops with fresh growing medium each season,[19] or a 1:8 ratio for more general use[20]), it can be applied directly to soil as a fertilizer. The fertilization effect of urine has been found to be

comparable to that of commercial fertilizers with an equivalent NPK rating.[21] Concentrations of heavy metals such as lead, mercury, and cadmium, commonly found in solid human waste, are much lower in urine.[22] The more general limitations to using urine as fertilizer then depend mainly on the potential for buildup of excess nitrogen (due to the high ratio of nitrogen),[19] and inorganic salts such as sodium chloride, which are also part of the wastes excreted by the renal system. The degree to which these factors impact the effectiveness depends on the term of use, salinity tolerance of the plant, soil composition, addition of other fertilizing compounds, and quantity of rainfall or other irrigation.

Urine after four months of storage, ready to be used in gardening activities (note the colour and turbidity change compared to fresh human urine).

Urine can also be used safely as a source of complementary nitrogen in carbon-rich compost.[20]

Urine typically contains 70% of the nitrogen and more than half the phosphorus and potassium found in urban waste water flows, while making up less than 1% of the overall volume. If urine is to be collected for use as a fertiliser in agriculture, then the easiest method of doing so is with sanitation systems that utilise waterless urinals, urine-diverting dry toilets (UDDTs) or urine diversion flush toilets.[23] Thus far, source separation, or urine diversion systems have been implemented in South Africa, China, Sweden and many other countries.

Fresh human urine after excretion

"Urine management" is a relatively new way of closing the cycle of agricultural nutrient flows (also called ecological sanitation or ecosan) and - possibly - reducing sewage treatment costs and ecological consequences such as eutrophication resulting from the influx of nutrient rich effluent into aquatic or marine ecosystems.[24] The risks of using urine as a natural source of agricultural fertilizer are generally regarded as negligible or acceptable.

It is unclear whether source separation, urine diversion, and on-site urine treatment can be made cost effective; nor whether required behavioral changes would be regarded as socially acceptable, as the largely successful trials performed in Sweden may not readily generalize to other industrialized societies.[21] In developing countries the use of whole raw sewage (night soil) has been common throughout history, yet the application of pure urine to crops is still rare.

Cleaning

Because urea in urine breaks down into ammonia, urine has been used for the cleaning properties of the ammonia therein. In pre-industrial times urine was used – in the form of *lant* or aged urine – as a cleaning fluid.[25] Urine was also used for whitening teeth in Ancient Rome.

Gunpowder

Urine was used before the development of a chemical industry in the manufacture of gunpowder. Urine, a

nitrogen source, was used to moisten straw or other organic material, which was kept moist and allowed to rot for several months to over a year. The resulting salts were washed from the heap with water, which was evaporated to allow collection of crude saltpeter crystals, that were usually refined before being used in making gunpowder.[26]

Survival uses

The *US Army Field Manual*[27] advises *against* drinking urine for survival. These guides explain that drinking urine tends to worsen rather than relieve dehydration due to the salts in it, and that urine should not be consumed in a survival situation, even when there is no other fluid available. In hot weather survival situations where other sources of water are not available, soaking cloth (a shirt for example) in urine and putting it on the head can help cool the body.

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*). The Vickers machine gun, used by the British Army during World War I, required water for cooling when fired so soldiers would resort to urine if water was unavailable.[28]

Urban legend states that urine works well against jellyfish stings. This scenario has appeared many times in popular culture including in the *Friends* episode "The One With the Jellyfish", an early episode of *Survivor*, as well as the films *The Real Cancun* (2003), the *The Heartbreak Kid* (2007) and the *The Paperboy* (2012). However, at best it is ineffective, and in some cases this treatment may make the injury worse.[29][30][31]

Tanning

Tanners soaked animal skins in urine to remove hair fibers—a necessary step in the preparation of leather.

Textiles

Urine has often been used as a mordant to help prepare textiles, especially wool, for dyeing. In the Scottish Highlands and Hebrides, the process of "waulking" (fulling) woven wool is preceded by soaking in urine, preferably infantile.[32]

Commercial collection

Because urine has so many commercial applications (making medications, making fertilizers, and so on), its systematic collection and sale can be worthwhile in some commercial contexts. In urine diversion systems, toilets divert the urine away from the sewerage route that it would otherwise take; instead, it flows into containers for pickup. Such businesses exist in some places where extensive sewerage systems do not. They are rare in places where nitrogenous wastes can instead be collected at sewage treatment or wastewater treatment plants.

History

Ancient Romans used fermented human urine (in the form of lant) to cleanse grease stains from clothing.[33] The emperor Nero instituted a tax (Latin: *vectigal urinae*) on the urine industry, continued by his successor, Vespasian. The Latin saying *Pecunia non olet* (money doesn't smell) is attributed to Vespasian – said to have been his reply to a complaint from his son about the unpleasant nature of the tax. Vespasian's name is still attached to public urinals in France (*vespasiennes*), Italy (*vespasiani*), and Romania (*vespasiene*).

Alchemists spent much time trying to extract gold from urine, which led to discoveries such as white phosphorus by German alchemist Hennig Brand when distilling fermented urine in 1669. In 1773 the French chemist Hilaire Rouelle discovered the organic compound urea by boiling urine dry.

Image of two facing pages of the illuminated manuscript of "Isagoge", fols. 42b and 43a. On the top of the left hand page is an illuminated letter "D" - initial of "De urinarum differencia negocium" (The matter of the differences of urines). Inside the letter is a picture of a master on bench pointing at a raised flask while lecturing on the "Book on urines" of Theophilus. The right hand page is only shown in part. On its very bottom is an illuminated letter "U" - initial of "Urina ergo est colamentum sanguinis" (Urine is the filtrate of the blood). Inside the letter is a picture of a master holding up a flask while explaining the diagnostic significance of urine to a student or a patient. HMD Collection, MS E 78.

Society and culture

Language

The English word *urine* (/ˈjʊərɪn/, /ˈjɜːrɪn/) comes from the Latin *urina* (*-ae, f.*), which is cognate with ancient words in various Indo-European languages that concern water, liquid, diving, rain, and urination. The onomatopoetic term "piss" was the usual word for urination before the 14th century. "Urinate" was at first used mostly in medical contexts. "Piss" continues to be used, but is considered vulgar; it is also used in such colloquialisms as "to piss off" and "piss poor", and the slang expression "pissing down" to mean "heavy rain". Euphemisms and expressions used between parents and children (such as "wee", "pee", and many others) have long existed.

See also

- Drinking urine (urophagia)
- Ureotelic
- Urine therapy
- Urolagnia, an attraction to urine

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