Pumping Water For Ponds

Tom Dorn
UNL Extension Educator

Occasionally, I visit with an acreage owner who would like to build a small fishing/swimming pond on their property, but their land area or topography is such they cannot count on surface runoff or natural springs to contribute any significant portion of the water needed to fill the pond or keep it full. Eventually, the discussion turns to the feasibility of using a well to pump the water for the pond. Invariably, the acreage owner is surprised by the amount of water it takes.

Let's crunch some numbers for a square pond 150 feet on a side. This pond would have a surface area of just over half an acre. If the depth in the middle of the pond is 10 feet and the sides have a 1:3 slope (one foot vertical drop for each three foot horizontal run), the volume of the pond would be 153,000 cubic feet or a little over 1.1 million gallons.

Domestic pumps usually deliver between 8–12 gallons per minute (gpm) but let's assume the well driller can find an adequate aquifer and installs a 20 gpm pump. Assuming the full 20 gpm flow goes only to the pond (not split between domestic needs and the pond), it would take between 40–60 days of continuous operation to fill the pond initially, depending on initial seepage losses.

If we assume 30 inches of direct annual rainfall per year but no appreciable runoff into the pond, the evaporation and seepage losses not made up by rainfall will average about 1/4-inch per day, year round. A 1/4-inch of loss per day over a half acre is equal to 3,400 gallons of water per day. This would require running the 20 gpm pump about 1,000 hours a year to keep the pond full.

Each half acre pond requires about 1.1 million gallons of water to fill initially and about 1.2 million gallons of pumped water a year to keep full. By way of comparison, a family of four will use about 250 gallons of water per day (91,250 gallons per year) for domestic uses. If the family also irrigates a 10,000 square foot (0.23 acre) lawn an average of 3/4-inch per week from May 1 through September 30, the total water used for the acreage more than doubles, (194,000 gallons).

A half-acre pond, therefore, "consumes" about as much water to fill initially as a family of four would have used for the household and lawn in six years. It will then require as much water each year to keep full as the family would have used in 6.5 years. A question I always ask an acreage owner considering a groundwater fed pond are, "Is this a sustainable use of our limited groundwater resource in eastern Nebraska?"

Natural Sources of Nitrogen for Plant Growth

Tom Dorn
UNL Extension Educator

Some plants "make their own nitrogen." If a legume (i.e., clovers, soybeans, alfalfa) is colonized by certain strains of Rhizobium bacteria, nodules will form on the plant roots where the bacteria live and reproduce. Within these nodules, a symbiotic relationship develops between the bacteria and the host plant. The bacteria utilize plant sugars as a source of energy and, in turn, "fix" nitrogen, converting nitrogen gas in the soil into forms of nitrogen that can be used by the plant. Once nodules form, the plant usually receives all of the nitrogen necessary for plant growth from that "fixed" by the bacteria. When planting a legume crop, UNL recommends inoculating the seed with the appropriate strain of Rhizobium bacteria unless the same legume crop has been planted in the field within the last three years. Given the small expense for inoculant, especially as compared to making a nitrogen fertilizer application in the absence of sufficient nodules to supply the needs of the crop, many folks will "play it safe" and inoculate every time they plant a legume.

Other crops, including all grass crops (e.g., corn, sorghum, wheat, forage grasses, etc.) and non-leguminous broadleaf crops (e.g., sunflowers, potatoes, sugar beets, cotton, etc.) are not colonized by nitrogen fixing bacteria and must obtain the nitrogen they need from the soil.

In addition to nitrogen fixed by Rhizobium bacteria, other natural sources are used as a source of nitrogen. These sources include: mineralization of organic matter which releases nitrogen that can be utilized by plants and nitrogen released as plant residues are broken down in the soil.

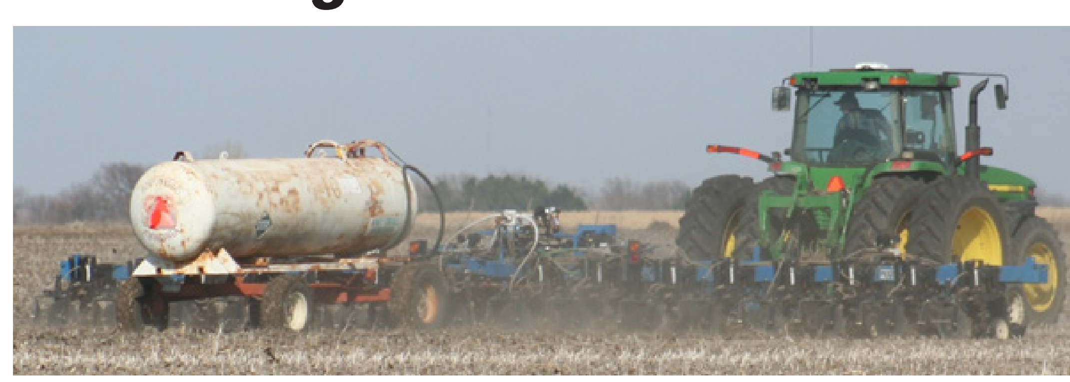
Animal waste is a good source of natural nitrogen as well. Barnyard or poultry manure and other animal waste products (e.g., bat guano) were used as a source of supplemental nitrogen long before inorganic nitrogen fertilizer came into popular use. Biosolids, a bi-product of the sewage treatment process, are utilized by many farmers in Lancaster County. Manure and biosolids supply nitrogen, phosphorus and many other nutrients required for plant growth. Repeated applications of manure and/or biosolids also increase soil organic matter levels over time and improve water infiltration and cation exchange capacity in the soil.

Organic Sources of Nitrogen

Composted plant residues, legume crops, such as red clover or vetch are plowed under as green manure and animal wastes are used as a source of nitrogen by organic crop producers. A small amount of nitrogen (a few pounds per acre per year) is also contributed by rainfall in the form of nitric acid (HNO_3), which when dissolved in the water in the soil disassociates into hydrogen and nitrate ions. The nitric acid is formed when nitrogen and oxygen gases are combined with rain water by the intense heat of a lightening bolt during a thunderstorm.

Commercial Nitrogen Fertilizer Sources

Tom Dorn
UNL Extension Educator



Green plants require more nitrogen than any other nutrient with the possible exception of potassium *(see Table 1).*

TABLE 1.
Total Crop Removal, lb/acre of Essential Soil Nutrients by a 150 bushel corn crop.

Nitrogen	200
Phosphorous (P_2O5)	85
Potassium (K_2O)	200
Calcium	42
Magnesium	44
Sulfur	25
Zinc	0.15
Iron	0.10
Manganese	0.08
Boron	0.06
Copper	0.05
Molybdenum	0.03
Chlorine	unknown

The air we breathe is about 78% nitrogen in the form of N_2 gas and about 21% oxygen in the form of O_2 gas. The remaining one percent of the atmosphere is a combination of all the other gases, (including carbon dioxide which is the source of carbon used by green plants). Even though there are 33,000 tons of nitrogen in the atmosphere over every acre on earth, the nitrogen gas is so chemically stable, plants cannot directly use it as a nutrient. Plants readily take up and use two forms of soil nitrogen, ammonium (NH_4^+) and nitrate (NO_3^-). Other forms of nitrogen must be converted to one of these compounds by natural or artificial means before plants can utilize them directly as a source of nitrogen for plant growth.

Anhydrous Ammonia

Anhydrous ammonia (NH_3) is produced commercially by reacting nitrogen gas (N_2) from the atmosphere in the presence of a catalyst with steam and with methane (natural gas, CH_4). The tonnage of anhydrous ammonia used in agriculture is greater than any other form of nitrogen fertilizer due to its lower cost per pound of nitrogen and its relative nutrient density (82% nitrogen by weight) which keeps the transportation cost per ton of nitrogen as low as possible.

Anhydrous ammonia is a gas at normal temperatures and atmospheric pressure, but converts to the liquid state when sufficiently pressurized. The need for pressurized containers and additional personal safety precautions reduces some of the advantages for anhydrous ammonia over more easily handled forms of nitrogen. All other forms of inorganic commercial nitrogen fertilizer are derived from anhydrous ammonia. They are more expensive per pound of nitrogen because of the additional processing steps involved in their manufacture and greater transportation costs because they have lower nutrient density (pounds of Nitrogen per pound of product) than anhydrous ammonia. These other forms of nitrogen fertilizer have advantages in terms of personal safety and ease of storing, handling, and application which make them attractive to many farmers in spite of the higher cost per pound of nitrogen .

Urea and Urea - Ammonium Nitrate

Urea ($CO(NH_2)_2$) is produced by combining anhydrous ammonia (NH_3) with carbon dioxide (CO_2). (Carbon dioxide (CO_2) is a byproduct of the anhydrous ammonia production process. It is produced by combining oxygen from the air (O_2) with the carbon atom that remains after stripping the hydrogen from the methane molecule). Fertilizers which contain urea and urea-ammonium nitrate (UAN) solution are the most widely-used nitrogen fertilizers in Nebraska after anhydrous ammonia. Dry pelletized urea is popular as a nitrogen fertilizer compared to other forms because of its relatively high nitrogen content (46% of the total weight is nitrogen), good storage and handling properties and widespread availability.

Urea-ammonium nitrate (UAN) is made by dissolving urea and ammonium nitrate in water. This results in an aqueous solution usually containing 28% nitrogen by weight (a more concentrated product containing 32% is also available in some locations). Liquid UAN solution is popular because of the versatility of a liquid fertilizer source, as well as widespread availability. The urea form of nitrogen cannot be utilized directly by plants. It must first be converted to the ammonium form by chemical processes in the soil.

Ammonium, in turn, may be directly used by the plant or converted to the nitrate form by microbiological processes in the soil. The conversion of urea ($CO(NH_2)_2$) to ammonium (NH_4)$^+$ occurs in a two-step process. When the urea combines with water (hydrolyzes) it forms ammonium carbonate ($(NH_4)_2CO_3$). Ammonium carbonate is unstable and decomposes to form ammonia gas (NH_3) and carbon dioxide (CO_2). The ammonia gas produced is chemically identical to anhydrous ammonia. If the ammonia gas is in physical contact with water, it reacts to form the ammonium ion (NH_4^+). If the ammonium ion is in contact with the soil, it is attracted to the negatively charged clay and organic matter particles and is held in the cation exchange complex.

Broadcasting urea-based fertilizers without incorporating them with tillage carries the risk of nitrogen loss to the atmosphere by ammonia volatilization. If just enough moisture is present to hydrolyze the urea but not enough to convert it to ammonium and carry it to the soil, the ammonia gas can escape into the atmosphere (volatilize). Volatilization is favored by high soil pH, warm temperatures, wet soils under drying conditions and crop residues that insulate the urea from the soil. Under extremely unfavorable conditions,

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