JCCC Honors Journal

Volume 3
Issue 2 *Spring 2012*

Article 4

2012

JCCC Storm-Water Treatment System: An Analysis and Botanical Review

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Abstract
This paper presents how Johnson County Community College (JCCC) uses plants as part of a naturally sustainable storm-water treatment system to manage the quality and quantity of the storm runoff leaving the campus. As the essay is intended for public education, background information about the water cycle, watersheds, the contamination of water resources and biological water treatment are presented. Additionally, information specific to the JCCC system is provided, including project funding, individual system components and botanical information about the plant species and families used in the treatment process. Data analysis from many sources reveals that biotic treatment systems are effective, but the system at JCCC extends beyond that. The system presents concepts that have nearly limitless applications when paired with creativity and concern about water quality and conservation.

Faculty mentor: Steven Giambrone

Johnson County Community College is home to over two million square feet of impermeable surfaces, that is, surfaces that do not absorb water. The college recognized that the amount and quality of the water running off these surfaces was a concern and began to develop a conceptual water-management landscaping plan. One part of this broad plan was the construction of sustainable storm-water retention and treatment facilities (Criner). In early 2009, after the announcement of the American Reinvestment and Recovery Act (ARRA), the college saw an opportunity to bring this idea to fruition. The ARRA was a stimulus package aimed at economic recovery during the height of the recent recession. This type of package is designed to boost the economy by means of the government injecting money into it via grants, loans and subsidies. Programs seeking to improve environmental conditions or overall infrastructure improvements within the United States were a focus of the act (The Recovery Accountability and Transparency Board). A proposal was put forth and was approved in May 2009 by the college board of trustees. The project would cost approximately $700,000; the ARRA stipulated that if the college would provide 20% of the funds the federal government would grant the difference. The total amount granted to the college by the federal government was $528,500 (The Recovery Accountability and Transparency Board). The remaining funding totaled $140,000. A student supported “green fee” of $1 per credit hour supplied $100,000 to the project, and the schools operating budget contributed $40,000 (Criner).

The general function of the storm-water management system is to control the quality and quantity of water runoff from impermeable surfaces on the southeastern quadrant of campus. These surfaces mostly consist of the parking lot, but also include rooftops, roads and paved walkways. The system intake per inch of rain on campus is approximately 273,000 gallons. On average, Johnson County records 3 inches of rain in a 24-hour period once a year, with the highest recorded 24-hour rainfall total exceeding 7 inches (National Weather Service Weather Forecast Office).

When water falls to earth as precipitation, there are three available routes for it to follow. The first is simply to evaporate, returning to the atmosphere in a gaseous state. Second, the water can infiltrate, or percolate, into the ground where it accumulates thus creating an aquifer (commonly referred to as groundwater). Aquifers store water, supply water to springs and natural lakes, and discharge water into oceans. Perhaps the most important attribute of an aquifer is water storage, as this is a major source of drinking water for the human population. Since the ground can only absorb so much water, the excess will follow gravity and flow downhill; this excess is referred to as runoff and is the third pathway of precipitation. Runoff travels over ground into ditches and streams, flowing into creeks, then rivers, until it reaches the ocean. The area of land that drains into a particular waterway is the watershed of that waterway. For example, JCCC's campus drains into Indian Creek, so it is located in the Indian Creek watershed. Indian Creek drains into the nearby Blue River; ergo JCCC also is located in the Blue River watershed. Following that pattern, JCCC is also located within the watersheds of the Missouri and Mississippi Rivers. Each successive waterway has a larger watershed, comprised of the combined preceding watersheds.

In an unpaved tract of land, much of the precipitation soaks into the ground, percolating through the soil and then the rock below, eventually reaching the aquifer. Each step of the way the water is filtered more and more, first by a layer of vegetative matter like grass or tree roots, then by smaller organisms present in soil, the soil itself and finally by bedrock deposits far beneath the ground . Plants, bacteria and fungi use the water and some of its contents, like nitrogen and phosphorus to function, grow and reproduce. Although plants and microorganisms possess the capacity to remove some metals and metalloids, the water still contains trace amounts of these inorganic particles, such as lead, copper and mercury. Chemicals present in the soil (specifically humus-rich topsoil and dense clay soils), gravel layers and bedrock react with inorganic particles (Washington Department of Transportation 1). This process renders the particles immobile, thus protecting the aquifer from contamination.

When large spans of ground are paved over, the percolation process is impeded. Water that cannot soak into the ground is diverted as extra runoff, and must travel over ground to the nearest ditch, stream, or in many cases, into a storm sewer. When a heavy downpour occurred at JCCC prior to the installation of the storm-water treatment system, multiple acres of surface area drained into curbside inlets that merged into a single pipe. The pipe then combined with other storm sewers in the surrounding residential areas, finally depositing tremendous amounts of untreated runoff into Indian Creek. This water contains contaminants including fertilizers and automotive byproducts (i.e. oil, anti-freeze and heavy metals). These substances have the potential for negative impact upon biological systems ranging from aquatic habitats to neural development in human infants. Additionally, the sheer amount of water is problematic. Overloading the capacity of a watershed can artificially increase flooding, erosion and sediment accumulation in waterways.

The use of storm-water retention or treatment systems can address these concerns, and an array of treatment options exist. Conventional treatment systems employ the use of techniques similar to sanitary sewage treatment; screen filtration of large solids, settling tanks for removal of smaller solids, skim tanks that allow floatable contaminants like oil to be removed from the top of the water, biological treatment to reduce nutrients and finally chemical treatment to reduce microbial presence. Sadly, the implementation of such systems for storm-water treatment is more the exception as opposed to the rule. To many people the benefits do not justify the cost of constructing and operating an industrial storm-water processing facility and the large-scale infrastructure changes that would be required to deliver water for treatment. This is reasonable considering reduced government budgets and overall public resistance to tax or price increases.

Fortunately, advances in the integration of environmental concerns into the fields of science and engineering have given way to the development of alternative options to traditional treatment. Beginning in 1985 there has been increased mainstream acceptance of the use of wetlands as a more sustainable water treatment option for storm runoff (Kadlec 11). These technologies utilize natural processes of plants, bacteria, fungi and even abiotic substances (inanimate, environmental components) like sand, gravel and stone to treat contaminated water. One factor that virtually all these types of systems have in common is the use of wetlands. Wetlands are effective water purification systems for many reasons, the most obvious being the capacity to retain, and to slowly discharge, large amounts of water (Horne 14). Other reasons wetlands are effective include high microbial biodiversity (algae, bacteria, zooplankton), the presence of areas with and without oxygen (aerobic and anaerobic) and hardy, fast growing plants capable of tolerating high levels of pollutants.

Bioremediation is defined as the use of biological agents, such as bacteria or plants, to remove or neutralize contaminants, as in polluted soil or water. The term Phytoremediation refers specifically to role of plants in performing these processes (Epuri, Sorensen 201). In most cases, bioremediation is a more accurate term, because nearly every plant will affect the surrounding environment in a way that creates habitat for microorganisms that aid in remediation, especially of carbon based compounds and heavy metals.

Concerns Regarding Water Contaminants

Nutrients are the most common pollutants found in waterways in the United States (Horne 22). It seems counterintuitive to consider nutrients as pollutants since all life requires these compounds to function, grow and reproduce. The problem lies within the amount of nutrients and the concentration in which they are introduced into our streams, lakes and rivers. There are several sources of these pollutants; the most severe sources are runoff from industrial agriculture and livestock production, while the most preventable source is residential lawn treatment. In the cases of industrial livestock production and industrial agriculture, livestock waste and fertilizers applied to crops are washed by rainwater into the waterways. As the population (and therefore demand for food) increases, this problem will compound. Once introduced, these chemicals create a sometimes-catastrophic domino effect within aquatic ecosystems. Eutrophication is the process in which excess nutrients create an imbalance in natural waterways (Cunningham, Cunningham 399). When high levels of nutrients are present, algae feed on them causing rampant growth referred to as algal blooms (red tides are well-known examples of marine algal blooms). Eventually the algae become so prevalent that light cannot penetrate into the water. As all plants need light to carry out photosynthesis, the algae eventually perish. The dead algae then become fodder for microscopic decomposing organisms, known as detritivores. These organisms consume oxygen, and as they fervently reproduce the demand for oxygen increases unsustainably. Water with drastically reduced oxygen levels is referred to as anoxic water; this water is not capable of sustaining oxygen dependent life forms, often resulting in asphyxiation of large numbers of aquatic organisms. The massive fish kills that anoxic waters cause have caught some media attention of late, however little information is provided regarding the source of these problems: the introduction of excess nutrients. Artificial wetlands are an effective and low-maintenance solution to this problem. In these systems, water is retained instead of rushing off to the nearest creek or stream. While water is within the manmade wetland, plants in the system absorb and consume the nutrients, thus rendering the outgoing water less harmful to natural aquatic environments. Specific plants are chosen depending on the type of wetland constructed and the climate where it is located. All plants ideal for nutrient removal have similar traits, namely the capacity for rapid and vigorous growth and tolerance to pollutants in soil and water.

Biomagnification refers to the increase in concentration of persistent toxins (substances that do not degrade within an organism) through successive levels of the food chain (trophic levels) (Cunningham, Cunningham 168). The process of biomagnification is driven by the phenomenon of organisms absorbing and accumulating persistent toxins from their environment. Persistent toxins include heavy metals and metalloids (inorganic pollutants) such as mercury and lead, and certain organic compounds including pesticides, gasoline additives and automotive exhaust byproducts. The first level of any food chain consists of producers, either terrestrial plants like grass or aquatic plants like algae. When plants accumulate toxins from their surroundings, these toxins are transferred into the subsequent trophic level when the plant is eaten by a primary consumer. The primary consumer absorbs toxins from every producer it eats, as well as from the environment. This results in exponentially higher concentrations of toxins within the consumer. This process is repeated with each successive trophic level. The amount of toxins in the first one or two levels may not be high enough to cause problems for the organisms, but as concentrations increase, so does likelihood of complications. One well-publicized example of biomagnification is the effect of the pesticide DDT in raptors (carnivorous birds). Below is a table showing the concentration of DDT through trophic levels of a river ecosystem.

Table 1

DDT in Trophic Levels

Sample Source	Concentration of DDT
Water	0.003 parts per billion
Zooplankton	0.04 parts per million
Small fish	0.5 parts per million
Large fish	2 parts per million
Fish eating birds	25 parts per million

Source: Cunningham, Cunningham 168

While the effects on lower consumers were not apparent, the numbers of hawks and eagles declined dramatically in the United States until the use of DDT was banned by the Environmental Protection Agency in 1972 (Environmental Protection Agency). The effects of biomagnification are not only a concern to fish and birds, but to humans as well. Humans are apex consumers and are not immune to the potentially harmful buildup of persistent toxins. The most effective way to manage these toxins is to attempt to prevent them from being introduced in the first place. Specific plants have proven to be effective at the removal of heavy metal and metalloid contaminants; these plants are referred to as hyper-accumulator species. These plants take in metals and metalloids present in the water absorbed by the roots (Horne 30). The contaminants are stored indefinitely within cellular structures called vacuoles. Rhizobacteria and mycorrhizal fungi (microorganisms living symbiotically with plant roots) have proven to be the most effective organisms at remediating persistent organic compounds such as pesticides and polyaromatic hydrocarbons (Wetzel, Banks, and Schwab 255).

Heavy metals are one of the areas of greatest concern at JCCC. Pollutants that fall into this category are mostly byproducts of automobiles on campus. Specific contaminants include zinc, cadmium, selenium and copper. Metals accumulate on roads and parking lots during periods of dry weather; during the following rainfall these metals are washed into the municipal storm sewer systems. In most areas that have separate sanitary sewer and storm sewer systems, including the majority of Johnson County, storm runoff is directly deposited into waterways with no filtration. While hyper-accumulator plants have been used successfully to immobilize these contaminants, they are not the most cost-effective or efficient method of inorganic remediation. One abiotic process that is extremely efficient is the chemical reaction between sulfides and metals (Horne 20). Sulfides are released when organic matter decomposes in an anoxic environment (Washington Department of Transportation 2). Conveniently, wetlands are characterized by the presence of both of these factors. Sulfides are negatively charged ions (anions) that react with almost all metal ions (cations); the reaction that occurs is a precipitate reaction, where two dissolved reactants form a solid insoluble product. Once the heavy metal or metalloid contaminant is in insoluble form it is immobilized, preventing contamination of waterways and the aquifer.

Organic pollutants can be either persistent or degradable and include benzene, ethylene glycol and hydrocarbons (gasoline and oil). These contaminants are also mostly the result of the large number of vehicles on campus. Vegetation can enhance removal of organic compounds in two ways. The most direct way in which plants remove contaminants from their environment is through uptake into the vascular system where compounds are either broken down and consumed, or are incorporated into the tissues of the plant. Plants also facilitate the removal of organic compounds indirectly by changing the soil around them. The root system of plants contain pores that produce secretions to lubricate and soften soils (Wetzel, Banks, and Schwab 255). These soil conditions are more conducive for the penetration and growth of the roots. In addition to improving the function of the roots, these excretions are a rich source of energy for copious and diverse amounts of microorganisms. The area of soil surrounding, and affected by, the root system is referred to as the rhizosphere. The increased amount and diversity of microorganisms present in the soil of the rhizosphere enable better degradation of organic compounds relative to bare, non-vegetated soil (Kruger, et al 73).

One glance around the banks of Indian Creek makes it glaringly obvious that when trash is not properly disposed of it will make its way into our waterways. Rainwater carries litter into storm sewers just as easily as the contaminants discussed above. This litter becomes entangled in tree branches and roots affecting growth; it can ensnare or be ingested by animals causing trauma or death, and can become a source of chemical pollution as it breaks down over time. At JCCC bioswales and soil within the storm-water system act as an infiltration medium thus preventing trash and litter from being deposited into the municipal storm system. However, the trash does accumulate and must be manually collected from time to time. The best way to control litter is simple: properly dispose of trash in the first place.

Types of wetlands

Emergent marshes are the simplest type of constructed wetland. This type of system generally consists of a shallow pond of collected water with regulated input and output and vegetation with the capacity to aid in removal of contaminants. Cattails (Family *Typha*) are the most common plant choice in this type of system for several reasons (Haag). Cattails naturally occur in dense stands along the banks and shallow waters of marshes, oxbow lakes and slow moving waterways (The Great Plains Flora Association 1237). The conditions of these habitats are similar to the conditions created within the artificial marsh. The capacity of cattails for rapid and aggressive growth makes them markedly effective at the removal of nitrogen and phosphorus, as nutrient removal is directly related to amount of biomass created (Horne 22) Prado Wetlands in Orange County, CA is the largest engineered wetland in the world. Since 1992, this emergent wetland system has been successfully used to reduce nitrate levels in the drinking water supply of a large portion of southern California. In a period of 2 to 7 days (depending on flow rate), the system can reduce nitrates from 10mg/l to 1mg/l. (Horne 24)

Floating wetlands consist of some area of open water and hydroponic growth systems. Hydroponic growth simply means that instead of plants being rooted in soil, water acts as the nutrient delivering medium. Buoyant grid-like platforms, generally constructed from plastic tubing, support and keep the plants afloat. This allows the roots to trail through the water, filtering out excess nutrients and organic compounds. The platforms also provide shade and habitat for aquatic life. Another benefit of this type of system is the relative ease of maintenance. If the vegetation becomes too heavy or dense, the platforms can be removed, thinned and replaced.

Vertical-flow wetlands vary widely in design. Generally, they consist of a retention pond that is filled from above and outlets through drainage pipe beneath the system, referred to as an under-drain. Vegetation planted on the banks of the pond, along with algae and bacteria present in the water, process contaminants in a similar manner to emergent marshes and floating wetlands. A key difference between these other types of wetlands and vertical-flow wetlands is the enhanced use of layers of compost and stone as a filtration medium. Directly below the water is a layer of compost, between the compost and the under-drain is a layer of limestone gravel. Compost is decomposed organic matter and is perpetually created by the vegetation surrounding and within the wetland. This thick, tar-like mud creates an oxygen barrier. The oxygen free habitat supplied by this barrier supports anaerobic bacteria that have shown to be effective in remediation of heavy metal and organic contaminants (Lelie, et al 267; Wetzel, Banks, Schwab 255). The compost layer also regulates the flow of water into the limestone layer. A chemical component of limestone is calcium carbonate ($CaCO_3$). This is important for two reasons. First, $CaCO_3$ neutralizes acidic water; secondly, it reacts with dissolved phosphorus (a nutrient contaminant) in the water, rendering it immobile (Erickson 16).

Horizontal subsurface flow wetlands differ from other types of wetlands in that there is no permanent exposed water. Instead of water being retained in a pond or marsh, water is channeled into one end of a retention basin. From here, the water flows below ground through highly permeable, engineered soil, traveling laterally into a drainage system on the end of the basin opposite the inlet. The soil bed is planted with large amounts of flora. The roots of the plants form a dense network, transforming the entire bed into a single rhizosphere. In this type of system decaying vegetative matter supply sulfides for immobilization of metals, plants uptake excess nutrients, and rhizobacteria and mycorrhizal fungi decompose organic compounds. Underground water treatment systems are preferable in urban or suburban areas because of public health and safety concerns, namely mosquitoes and the chance of drowning. Because this type of wetland is effective at remediation without the drawbacks of open water wetlands, JCCC chose a horizontal subsurface flow wetland for the storm-water treatment system.

Components of JCCC System

The system at JCCC was designed not only for its intrinsic use, controlling quantity and quality of storm-water runoff, but also to showcase a multitude of low-maintenance and sustainable water treatment technologies. Below are brief overviews of the individual components found within this system.

Wetland/Bioretention cell – At approximately 10,000 square feet, it is the most conspicuous component of the system. As mentioned above, JCCC chose a horizontal subsurface flow wetland. It is located on the southern border of campus and is the final storage and treatment site for the storm-water gathered by the storm sewer system before it is discharged into the municipal storm-water sewer. Water from the southeast quadrant of campus is channeled to the cell, where it will spend a minimum of 2-3 days. During this time, the water is underground, slowly flowing through the rhizosphere of the plants in the basin, where the roots, the bacteria in the soil, and the soil itself clean the water, preparing it for introduction into the Indian Creek watershed. The engineers at Burns & MacDonnell designed this cell to process up to a two-year (statistical frequency of occurrence) 24-hour rain event (3.5-4" per 24 hours) at maximum treatment (2-3 day minimum in system). The system possesses partial treatment contingency up to ten-year 24-hour rain event (5-6"/24hours) and containment contingencies without treatment up to twenty five-year 24- hour rain event (6-7"/24 hours) (Haag).

Engineered soils are composed of a combination of soil types intended to serve a specific purpose. The basic ingredients of engineered soils are clay, humus and aggregates (sand, gravel or crushed stone). For example, soil where maximum drainage is desired would have a higher ratio of aggregate material, but if minimal absorption and maximum erosion resistance are desired, the ratio of clay would be increased. When a combination of attributes is needed to achieve a specific function, multiple soils of different compositions can be used in layers. For example, in a constructed subsurface flow wetland, the top layer of soil is amended with higher amounts of sand and topsoil, creating a rich yet quick draining soil in which the plants used for remediation thrive. Beneath this, a layer of larger aggregate allows the flow of treated water into the drainage pipe for discharge. By adjusting factors of soil composition, many functions can be achieved by the use of these types of soils.

Filtration tanks are relatively small, enclosed treatment systems. The tanks used in the JCCC storm system consist of a six-foot diameter cylinder wrapped in a second cylinder with an outside diameter of nine feet. The inner cylinder is the initial treatment area and contains six compartments, arranged like the sections of an orange, each containing a combination of gravel and sand. The water within the system travels counter clockwise using a series of specialized drains. In each compartment, the gravel and sand filter out contaminants. The first section uses a grease trap (an inverted elbow fixed to a horizontal drain) to prevent floatable contaminants such as oil from continuing to the next section. Each of the next four compartments has drains referred to as “skimmers”. These drains float on the surface of the water and drain to the bottom of the subsequent sections. In the final compartment of the smaller cylinder, water drains into the larger, non-sectioned, outer cylinder. This cylinder contains soil in which wetland flora are planted. The bacteria and plants living in the soil filter the water once more as it diffuses clockwise to the outlet located just below the initial inlet pipe. These systems require no external power or pumps as they are driven by gravity and the natural process of diffusion. Another benefit of these treatment systems is that they require very little maintenance. Specifically, the Storm-treat™ Treatment System used at JCCC requires only the biannual removal of sludge from filtration compartments and once every 10-15 years the aggregate used for phosphorus removal will reach maximum capacity and require replacement.

Bioswales utilize absorbent soil, dense low vegetation (like grass), and/or areas of stone. The ground is graded based on hydrodynamic calculations to slow and direct the flow of large amounts of water. The contour of the ground combined with absorbency of the soil determines the magnitude and direction of the flow. The grass and rocks act as filters by physically trapping larger contaminants such as litter and sediment. This effect is easily seen in the system at JCCC after a strong storm, i.e. litter amongst the rocks, cigarette butts, coffee cups, etc.

Below, outlined in yellow, is a stone bioswale flanked by Lance-Leaved Coreopsis *(Coreopsis Lanceolata)* in full bloom. Note the gradual slope and large gravel. The gravel traps debris while allowing water to gently flow into the retention basin.

Rain gardens are a convenient, aesthetically pleasing and efficient approach to water retention. Due to the relatively low cost of construction, variety of effective flora and minimal space requirements the applications for rain gardens are nearly limitless. Rain gardens are constructed with a depressed center and engineered soils for maximum absorbency. Nearly all the plants in rain gardens at JCCC are planted with native vegetation reducing the chance of introducing invasive ornamental species to the surrounding areas. An additional benefit of native plants is that they are low-maintenance and therefore cost-effective.

Pervious concrete is sponge-like in structure with relatively large holes throughout. These holes allow water to travel through the concrete into a drainpipe below. The water is then fed into the wetland instead of accumulating and adding to the problem of excess runoff. In the system at JCCC, this component is displayed by a sidewalk made of pervious concrete that surrounds the constructed wetland area. However, the uses of this as a building material are not limited to sidewalks. This product is composed of very high-strength concrete and is comparable in durability to conventional concrete. Since water is free to flow through the material, ice accumulation is negligible, making it ideal for residential use.

Botanical Review of Plants in the JCCC Storm-water System

With the exception of pervious concrete, plants are integrated into every component of the JCCC storm-water treatment system. In all, the system contains over 50,000 individual plants. There are 23 species planted (twelve discussed below), with additional species introduced from the surrounding environment.

All the plants in the system are native to the Great Plains, and most of them occur naturally in Kansas. Two families of plants of special significance constitute the majority of the flora in the system: Poaceae (the grass family) and Asteraceae (the sunflower family). Kansas is nicknamed “the sunflower state” and is known worldwide for its expansive grasslands, so it is logical that these two families represent the majority of the plants used in a system emphasizing native flora.

Poaceae is the most widely distributed plant family in the world (Bidlack, Jansky 471) and members of this family are found from the Arctic Circle (Cottongrass) to Antarctica (Antarctic Hair Grass). Antarctic Hair Grass is one of only two vascular plants native to Antarctica (Fries-Gaither). The success of the distribution of this family is due to some key adaptations. Grasses are divided into two groups, cool-season and warm-season. This seemingly simple difference is actually an amazing feat of adaptation. Warm-season grasses adapted to warmer, drier environments by evolving an entirely different process of photosynthesis called 4-Carbon Pathway (C-4 plants). The standard photosynthetic process is referred to as 3-Carbon Pathway (C-3 plants), and is a three step process, two light-dependent reactions and one light-independent reaction. C-4 plants possess specialized leaf anatomy (Kranz anatomy) that divides one step of the standard C-3 process into two. The 4-Carbon Pathway requires slightly more energy, but is much more efficient at higher temperatures (Bidlack, Jansky 174). Kansas is the native home to both warm and cool season grasses. Another anatomical adaptation found only in Poaceae are bulliform cells. These specialized leaf cells are also an adaptation to combat the effects of high temperatures and drought. Bulliform cells cause the blades of a grass to roll up laterally during periods of extreme heat for maximum water retention.

The vast distribution of Poaceae is impressive; however, it pales in comparison to the ecological and human significance of this family. Members of Poaceae tremendously important to human nutrition include cereal products (corn, wheat, rice, oats, etc.) and sugar cane. Over one billion tons of cereal products are harvested annually worldwide (Bidlack, Jansky 472). The predictability of grasses led to the development of agriculture and provided humans with stability, allowing human civilization to thrive. Grasses are tolerant to a wide variety of soil conditions, protect soil from erosion, provide food and habitat to wildlife and play an important role in cleansing water bound for aquifers. These traits make them desirable for use in phytoremediation.

With over 20,000 members, Asteraceae is the second largest family of all flowering plants (Bidlack, Jansky 470). Only the orchid family (35,000 species) exceeds the number of species within Asteraceae (Bidlack, Jansky 474). Well-known members of this family include daisies, sunflowers, marigolds, chrysanthemums and lettuce. Many members of Asteraceae are cultivated for use in flower gardens and food production. Examples of food products include sunflower seeds, sunflower oil, artichokes, lettuce and dandelions. While most people are familiar with the image of a sunflower, it may surprise many to know that the “flower” is not a flower at all. It is an inflorescence, or a collection of many tiny flowers called florets. There are two types of florets; disk florets are tightly packed within the center orb of the inflorescence (the brown part of a sunflower), while ray florets are on the outer edge of the inflorescence. The yellow “petals” of a sunflower are actually modified sepals (structures that resemble small leaves present at the base of a flower petal, these generally cover a bud before the emergence of a flower) of the ray florets. Members of this family are forbs, meaning they are plants that live multiple years (perennial), and that the part of the plant above ground dies each year after the first killing freeze. Forbs (specifically Asteraceae) are ideal for the storm-water treatment system not only because of their beautiful inflorescences, but also because the cyclic death of the above ground structures provide an excellent source of compost matter.

JCCC Storm-Water System Plants Index

Goldmoss Stonecrop

Genus/Species - *Sedum acre*

Family – Crassalaceae (orpine)

Distribution – Northern: Newfoundland, Canada west to British Colombia, Canada.

Southern: North Carolina west to Oregon.

Habitat – Sandy or rocky soils, succulent (fleshy) leaves allow success in very dry conditions.

Overall height – 10 cm.

Root system – shallow root system.

Leaf description – Dichotomous, opposite, simple, succulent leaves. Margins entire, tips obtuse, base obtuse and sessile.

Flower description – Sepals, petals, pistils 4-5, stamens 8-10 (twice the number of sepals) blooms June to August.

Propagation – by seed or rhizome (lateral underground stem capable of sprouting new growth).

Members of the Crassalaceae family and other succulents, such as cacti, utilize a third photosynthetic process called CAM (Crassulacean acid metabolism) photosynthesis. Many plants with this ability can also switch to the C-3 (standard) Pathway when conditions allow. CAM photosynthesis is an adaptation that allows plants in extremely hot or arid habitats to survive. This is done by performing only the light dependent steps of photosynthesis during the day, while light independent reactions (including gas exchange with the atmosphere) are done during the night when temperatures are lower. This drastically conserves water within the plant, as the stomata (structures that regulate gas exchange) remain closed during the heat of the day, which prevents water from diffusing into the atmosphere (Bidlack, Jansky 177).

Lance Leaved Coreopsis

Genus/Species - *Coreopsis lanceolata*

Family – Asteraceae (sunflower)

Distribution – Found throughout continental United States with exception of Rocky Mountain region.

Habitat – upslope or mid-slope, roadsides, sandy prairies, commonly found in fine to medium textured soils.

Overall height - 20-70 cm.

Root Depth – 15 cm minimum.

Leaf description – 5-20 cm long, decreasing in size from base to top, up to 2 cm wide. Simple, lanceolate shape; upper are leaves reduced and somewhat sessile.

Flower description – Blooms March – July. Long peduncle (flower stem) is closely proportionate to height of plant each bearing a single inflorescence. Disk and ray florets both yellow, up to 300 per inflorescence. Ligules of ray florets (false petals) are golden yellow, up to 10 cm in length.

Propagation – Seed.

Lance leaved coreopsis is commonly cultivated for use in landscaping or roadside plantings due to their drought tolerance, low nutrition requirements, and vibrant color.

Little Bluestem

Genus/Species - *Schizachyrium scoparium*

Family - Poaceae (grass)

Distribution – Northern: New England west to Washington. Southern: Florida west to Arizona.

Habitat – Often a dominant/co-dominant prairie species.

Overall height – 40 – 95 centimeters tall.

Root Depth – 80-190 cm.

Leaf description – Clump forming, blue-green early in season, turning to orange or rust colored after frost. Blades sometimes rolled or folded and range from 5-30 cm long, less than 6 mm wide.

Flower description – Blooms July – September. Culms (grass stems) erect and contain several inflorescences. Inflorescence spike/racemes shaped, meaning they are narrow with spikelets (grass flower) very near the stalk. Spikelets are generally in pairs.

Propagation – Seed.

Little bluestem is a perennial, warm season (C-4) grass common throughout North America. The combination of the abundance and palatability of this grass makes it a valuable feed source for the cattle industry. Wildlife depend on Little Bluestem for food and habitat as well. Deer and elk will feed on the leaves, while songbirds and small mammals consume the seeds. Birds like quail and prairie chickens use mid-height grasses such as this for cover and nesting material. The exceptionally deep roots of this grass reduce erosion in the sandy, dry soils in which it thrives.

New England Aster

Genus/Species - *Aster novae-angliae*

Family – Asteraceae (sunflower)

Distribution – Northern: New England west to Montana. Southern: Virginia southwest to central Alabama, Mississippi northwest to central great plains.

Habitat – stream banks, wet meadows, thickets, low areas and roadsides. Abundant on moist or drying sandy soils.

Overall height – 50 to 120 cm tall

Leaf description – Leaves simple, alternate, lanceolate, covered in coarse hair; on multiple, branched stems.

Flower description- Ligules of ray florets linear, obtuse tipped, ray florets up to 100, occur in multiple shades of purple, many disk florets ranging from yellow-orange to reddish purple.

Propagation – Seed or Rhizome

As is the case of many members of Asteraceae, New England Aster is commonly used in gardens. The brightly colored flowers draw butterflies and bees. While the plant has no nutritional value to humans, Native Americans used tea made from the roots to treat fevers and diarrhea.

Porcupine Sedge

Genus/Species - *Carex hystericina*

Family – Cyperaceae (sedge)

Distribution – Found throughout the continental United States, with exception of Nevada and deep South/Southeast.

Habitat - Swamps, shorelines, ditches.

Overall height - 20-100 cm.

Root Depth – short stout roots.

Leaf description – Grass-like in structure, 3-8 mm wide, rough, light green above, purple hue underneath, slender and triangular, sometimes drooping over inflorescence.

Flower description- spike structure inflorescence on stalk, multiple stalks per culm. Each inflorescence composed of nearly sessile perigynia (egg or pear shaped flower type unique to sedge family) up to 100 per spike.

Propagation – Seed.

The common name Porcupine Sedge is derived from the inflorescence produced by the plant. The mature inflorescence resembles a hybrid of a porcupine and a caterpillar. Each perigynia has two barbed, rigid teeth protruding outward; these teeth dry out and harden after the growing season forming what are commonly known as burrs. These burrs easily attach to animal fur, feathers, or clothing and the teeth are firm enough to puncture human skin. The barbed tips can become lodged within the skin causing extreme irritation and an itchy, tingling feeling.

Rice Cutgrass

Genus/Species - *Leersia oryzoides*

Family – Poaceae (grass)

Distribution – entire continental United States, most of Canada (excluding extreme north).

Habitat – found along ditches, streams, ponds, lakes and marshes.

Overall height – 40 to 110 cm.

Root Depth – 35 cm minimum.

Leaf description – Blades are 7 to 30 cm long, up to 20 mm wide. Surface scabrous (especially along margins).

Flower description – Flowers July to October, inflorescence panicle in structure (spreading, random), those occurring closest to base generally sheathed within top blade. Basal inflorescences are whorled (present in groups of three or more) becoming single and spiraling above.

Propagation – by seed or rhizome.

Rice cutgrass is a cool-season perennial grass with several unique traits. The plant gets its name from the abrasive blades that are rough enough to injure human skin. This is due to nearly microscopic teeth present along the margins of the blades. In spite of this, rice cutgrass is a highly palatable fodder for grazing animals. Another notable characteristic is the soil tolerance the species exhibits, namely that it will grow in extremely acidic soils (Ph as low as 3.0). The husks of rice cutgrass seeds are covered in bristles. This allows the seeds to cling to animal fur or clothing, thus aiding in dispersal.

Prairie Blazing Star / Thickspike Gayfeather

Genus/Species - *Liatris pycnostachya*

Family – Asteraceae (sunflower)

Distribution – Northern: Massachusetts west to North Dakota. Southern: Mississippi west to Texas.

Habitat – Open damp prairies.

Overall height – 50 to 150 cm.

Leaf description – Stems and leaves are pubescent (hairy). Leaves linear, arranged alternately, dark green in color with a lighter stripe down the middle of each, 10 – 40 cm long 1 cm wide. Length of leaves gradually decrease above basal leaves

Flower description – Blooms July to September. Large spike structured inflorescence, florets sessile, with purple bracts. White stamens extend outward from florets giving the spike a fuzzy appearance.

Propagation – Seed, corm; will also grow from cuttings

The bright color and copious florets make Prairie Blazing Star very attractive to butterflies and bumblebees. The seeds are eaten by songbirds and the corms by rodents.

The species has been reported to have uses in combating kidney disease and Native Americans used the corms to treat gonorrhea.

Prairie Dropseed

Genus/Species - *Sporobolus heterolepis*

Family – Poaceae (grass)

Distribution – Northern: New England west to Montana. Southern: North Carolina west to New Mexico.

Habitat – open woods, upland, and lowland prairies.

Overall height – 40 to 95 cm.

Root Depth – 30 cm.

Leaf description – Culms are slender, erect, clump forming. Blades folded, glabrous (smooth) to scabrous, 7-31 cm long, 1-3 mm wide.

Flower description – Blooms July to October. Inflorescence is open-panicle in structure; seemingly random in distribution about the culm.

Propagation – Seed.

Prairie Dropseed is a warm season grass and is used all over the campus of JCCC as native landscaping decoration.

Purple Coneflower

Genus/Species - *Echinacea purpurea*

Family – Asteraceae (sunflower)

Distribution – Northern: Connecticut west to Iowa. Central: Virginia west to Colorado. Southern: Florida west to Texas.

Habitat – Rocky Prairie and open woodland regions.

Overall height – 60 to 180 cm.

Root Depth – 60 cm minimum.

Leaf description – Leaves are15- 20 cm long up to 15 cm wide. From base: decreasing length; leaves lanceolate and stalked to ovate and sessile. Pubescent throughout.

Flower description – Inflorescence disk 3.5 cm in diameter with disk florets forming a brown, spiked dome. Ligule of ray florets are linear-lanceolate, generally drooping, 3-8 cm long, color ranging from pink (rare) to reddish purple.

Propagation – Seed.

Widely used by Native Americans and settlers as remedy for many ailments, including cough, sore throat, snakebites and gonorrhea. Modern studies have shown efficacy in boosting immune function in mouse cells.

Showy Goldenrod

Genus/Species - *Solidago speciosa*

Family – Asteraceae (sunflower)

Distribution – Northern: New Hampshire west to Wyoming. Southern: Georgia west to New Mexico.

Habitat – Prairies and open dry woodland often in rocky or clay soils.

Overall height – 30 to 150 cm.

Leaf description – Leaves thick, arranged alternately. Leaves ovate to lanceolate, 5-15 cm long 1-4 cm wide, decreasing in size above base.

Flower description – Blooms from August to October. Multiple inflorescences present within panicle with each floret containing 4-8 yellow ray florets and 4-5 disk yellow-brown florets.

Propagation – Seed.

Sweetflag

Genus/Species - *Acorus americanus*

Family – Araceae (arum)

Distribution – Northern: Newfoundland, Canada west to Alaska. Southern: Virginia west to Washington.

Habitat – Swamps and marshes.

Overall height – 90 to 120 cm.

Leaf description – Erect leaves 90-120 cm long, 4-10 mm wide, cross section of the leaves reveal them to be circular in shape, not hollow. Green leaves give way to sharp, stiff tips that are colored purple to black.

Flower description – Blooms May to August small primitive inflorescence protruding from leaf. Pistils and stamens both present.

Propagation – Mostly rhizomatous, seed.

Wild Bergamot

Genus/Species - *Monarda fistulosa*

Family – Lamiaceae (mint)

Distribution – entire continental United States except Louisiana and Florida.

Habitat – prairie hillsides, pastures, roadsides, and thickets, occasionally in open woodland.

Overall height – 30-120 cm.

Root Depth – 20 cm minimum.

Leaf description – Stems simple or branched, leaf margins serrate with shape varying from ovate to lanceolate. Size ranges from 3-10 cm long and 1-3.5 cm wide. Leaves always pubescent below, sometime above.

Flower description – Blooms June to August, true flowers solitary on end of branches, 1.5-3 cm across, petals pale to dark lavender; rarely white.

Propagation – Seed.

Wild Bergamot is a sweet-smelling, long blooming flower highly attractive to bees, leading to the alternate common name of Beebalm. Native Americans used this flower to perfume their hair and clothing. They also used the plant to treat many ailments including colds, fevers, stomach pains, respiratory difficulties and acne. Dried leaves are still used to make tea today.

Sources for individual species information: The Great Plains Flora Association; Haddock; USDA, NRCS.

All of these plants, along with the other processes of the storm-water treatment system previously discussed, work in concert to conserve and protect our water resources, while simultaneously improving the appearance of campus. The system as a whole provides the community with examples of the variety of simple things that can be done on any scale to control the impact humans have on their environment. The processes and technologies displayed within the system, paired with creativity, can be used by homeowners, businesses, schools, agricultural producers or anyone else willing to make an investment in their property or community. Simply creating awareness also benefits the community; if people do not know about the concerns associated with water quality, how can they take steps to improve it?

Examples of alternate uses of some of the components of the system include the use of filtration tanks for treating gray water to be reused for irrigation, native grass bioswales on steep areas with erosion concerns or constructed wetlands for parking lot runoff of businesses. Even ideas like retaining storm-water can be applied, as in the use of rain barrels to store discharge from gutters for lawn watering. By increasing the understanding of the concerns presented, people are empowered to make responsible personal decisions. Whether it is to ensure that trash makes it into the trashcan, or to choose alternate, less impactful methods of fertilizer such as compost or cattle manure; awareness is the first step of change.

This subject matter is especially important to me personally, as I grew up very close to Indian Creek, and spent much of my youth exploring this waterway and the surrounding areas. The more time I spent in the creek bottoms, the more I learned, and the more fascinated I became with the plants, animals and geology of the area. As the surrounding population grew and encroached upon my playground/laboratory, the woods were bulldozed, strip-malls, apartments and subdivisions were erected, and the creek changed. More and more trash collected along the banks, the water was rarely clear and smelled bad more often and fishing became less productive. These are just observations, with no data or involved study to confirm the findings, but it is comforting to know that some steps are being taken to protect the place that shaped me and the way I think about nature and the natural world.

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