Full Length Research Paper

Carbon dioxide (CO$_2$) utilizing strain database

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Culling of excess carbon dioxide from our environment is one of the major challenges to scientific communities. Many physical, chemical and biological methods have been practiced to overcome this problem. The biological means of CO$_2$ fixation using various microorganisms is gaining importance because database of their substantial role in reversing global warming. Carbon dioxide utilizing strain database (CSD) presents a comprehensive overview of microorganisms involved in biological fixation of carbon dioxide. As a part of this work, the wealth of information on CO$_2$ utilizing strains was first collected and was then managed within four classes, that is, microorganisms, genus listing, mechanisms and literature. The first two classes consolidate information regarding the microbial genus and species, while the later two provide information regarding the CO$_2$ fixing pathways and the taxonomic details of these organisms. The database also holds the current information about the issue. CSD can be used to gain information related to CO$_2$ fixing microbes. It can also contribute to devising biological strategies for reducing carbon dioxide from the environment. It introduces an innovative idea of exploring the potential of these bacterial strains for reversing global warming. The CSD can be accessed at http://csd.igib.res.in.

Key words: Carbon dioxide utilizing strain database (CSD), carbon dioxide, autotrophic microorganisms, global warming, biological fixation of CO$_2$, CO$_2$ fixing pathways.

INTRODUCTION

Global warming, the major upcoming environmental problem is caused mainly by rising concentration of greenhouse gases. As excess of everything has negative impact, excess of global warming too has its ill effects on our ecosystem. One of the major impacts of global warming is melting of ice caps at poles, which is responsible for rise in ocean level; this rise can even lead to flooding of coastal regions and disappearance of island. Rapid warming may also cause rise in sea level (Domingues et al., 2008), extinction of coral reefs (Kleypas et al., 1999; Hoegh-Guldberg et al., 2007), destruction of rain forest (Lewis, 2006), change in agricultural yield and even extinction of species such as polar bear (Courtland, 2008). These effects of global

warming are directly or indirectly linked to rising concentration of carbon dioxide in our atmosphere. So, there is a need for efficient and effective methods to halt this rising carbon dioxide. Till now, three measures, that is, physical, chemical and biological measures have been adopted to get rid of excess CO$_2$ from the atmosphere (Zevenhoven et al., 2006; Otsuki, 2001; Chang and Yang, 2003; Honjo, 1996; Murakami and Ikenouchi, 1997).

Biological fixation of CO$_2$ using microorganism has significant advantages over the other two approaches (Wang, 2008). Hence, the quest of researchers for the use of microorganisms for CO$_2$ sequestration has gained attention. Microbes, still the most unexploited group of organisms can act as a treasure of various unknown novel metabolic pathways. These pathways can offer a solution to many environmental problems through bio-remediation. The biomass and the byproducts produced by autotrophic microorganism through CO$_2$ fixation can be used for the production of biofuels, which can act as an alternative to fossil fuels (Bruce, 2008). As an effort to mitigate rising CO$_2$ concentration, the photosynethetic

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Abbreviations: **CSD**, Carbon dioxide utilizing strain database; **PHP**, hypertext preprocessor; **HTML**, hypertext markup language; **NCBI**, National Center for Biotechnology Information.
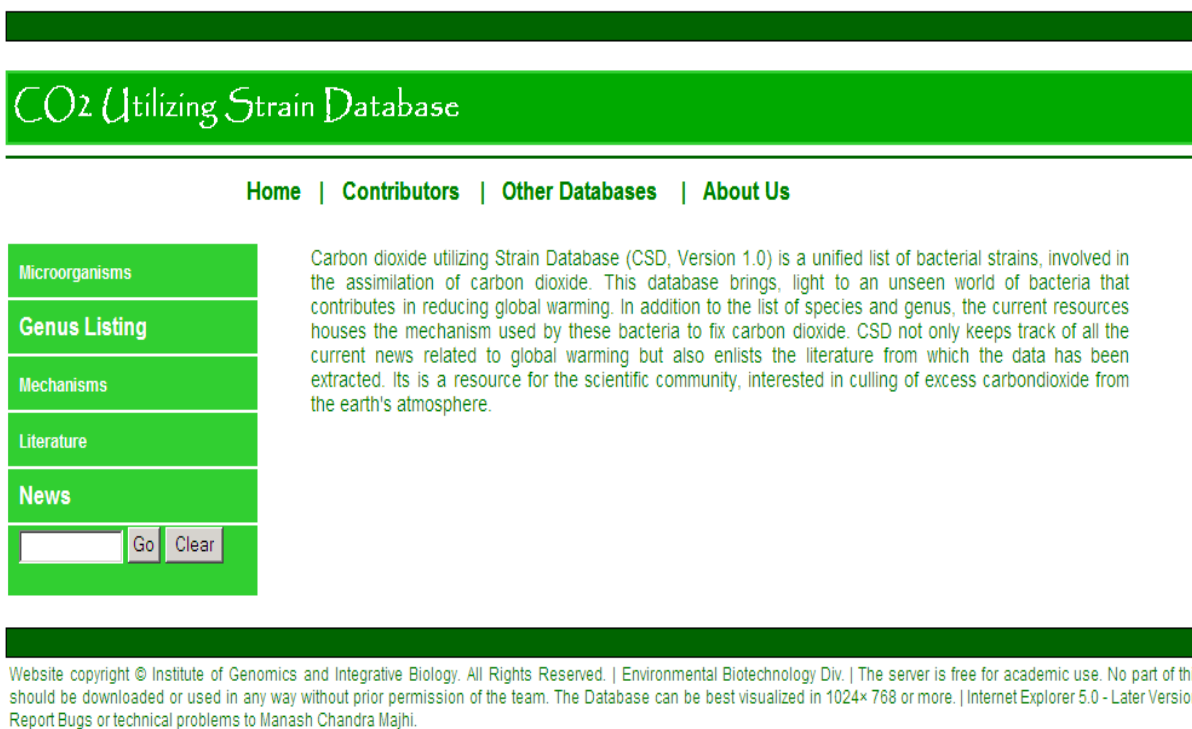
CO2 Utilizing Strain Database

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Microorganisms

Genus Listing

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[____] Go Clear

Carbon dioxide utilizing Strain Database (CSD, Version 1.0) is a unified list of bacterial strains, involved in the assimilation of carbon dioxide. This database brings, light to an unseen world of bacteria that contributes in reducing global warming. In addition to the list of species and genus, the current resources houses the mechanism used by these bacteria to fix carbon dioxide. CSD not only keeps track of all the current news related to global warming but also enlists the literature from which the data has been extracted. Its is a resource for the scientific community, interested in culling of excess carbondioxide from the earth's atmosphere.

Figure 1. Screen shot showing CSD web page.

activity of microalgae has been exploited. But, herein through this work, we are drawing the world's attention to the fact that besides plant and microalgae, there are some microbes (bacteria and archaea) that can also lower their surrounding CO_2 level (Jessup et al., 1998; Herter et al., 2002). Their efforts seem to be negligible but it will become significant in the coming years when there will be a need for a biological system that can fix greenhouse gases emitted from industrial process more efficiently than plants.

Till date, six autotrophic pathways have been reported in microorganism, through which the microbes can incorporate carbon dioxide as their cell carbon. These are the Calvin-Benson-Bassham cycle (Calvin cycle) (Thauer, 2007; Hügler et al., 2003), reductive tricarboxylic acid (TCA) cycle (Thauer, 2007; Hügler et al., 2003; Evans et al., 1966), reductive acetyl coenzyme A (CoA) pathway (Thauer, 2007; Hügler et al., 2003), 3-hydro-xypropionate/malyl-CoA cycle (Thauer, 2007; Hügler et al., 2003; Herter et al., 2002), 3-hydroxypropionate/4-hydroxybutyrate cycle (Thauer, 2007; Berg et al, 2007) and dicarboxylate/4-hydroxybutyrate cycle (Huber et al., 2008). Microbes which have CO_2 fixing capability can be used to develop biological technologies to reduce the level of CO_2 in the atmosphere (Tributsch, 2003). Carbon dioxide utilizing strain database (CSD) version 1.0 is developed on this idea to hold the current list of species available for CO_2 fixation and the related information, so that environmental scientist can have a quick access to all the information in a single place.

MATERIALS AND METHODS

Dataset and database development

To build such a database, the data was gathered from the research publications available at National Center for Biotechnology Information (NCBI) (Figure 2). The data was then incorporated into a conceptualized web based database. The backend of the databases was maintained in MySQL (http://www/mysql.com), a relational database management system. The web interface to access the database was written in hypertext preprocessor (PHP), hypertext markup language (HTML) and JavaScript. This setup was then deployed on an Apache HTTP Server (http://www.apache.org/) (Figure 4).

Database design and features

CSD web page acts as a modem between the user and the data available. The information in the database is usable through four web interface in the form of classes (Figure 1). First is "microorganisms", which enlist all the currently available autotrophic microorganisms. The data within the class microorganisms is divided into three columns. The first column enlists the names of the bacterial species which in turn are linked to the taxonomic browser of NCBI. The second and third column provides information about the bacterial strains and the mechanism used by them for CO_2 utilization (Figure 3). The genus of the autotrophic microbes listed in the first class is incorporated as "genus list" in the second class of the database. On selecting this class, a page containing the list of genera appears on the screen. For taxonomic details, each genus was linked to the taxonomy browser page of NCBI (Figure 3). The pathways through which these microorganisms fix carbon dioxide have been shown as a "mechanism" in the third class of the database. Some of these pathways have been linked to
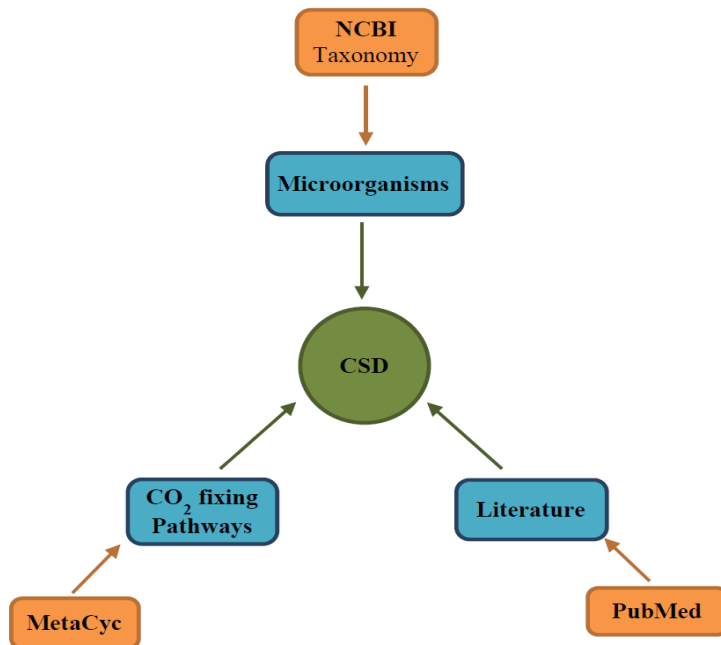
Figure 2. A diagrammatic representation of the components constituting CSD.

Figure 3. CSD web interface. (1) Microorganisms information and its interaction with MetaCyc pathway database. (2) Genus listing, species was linked to NCBI taxonomy browser.
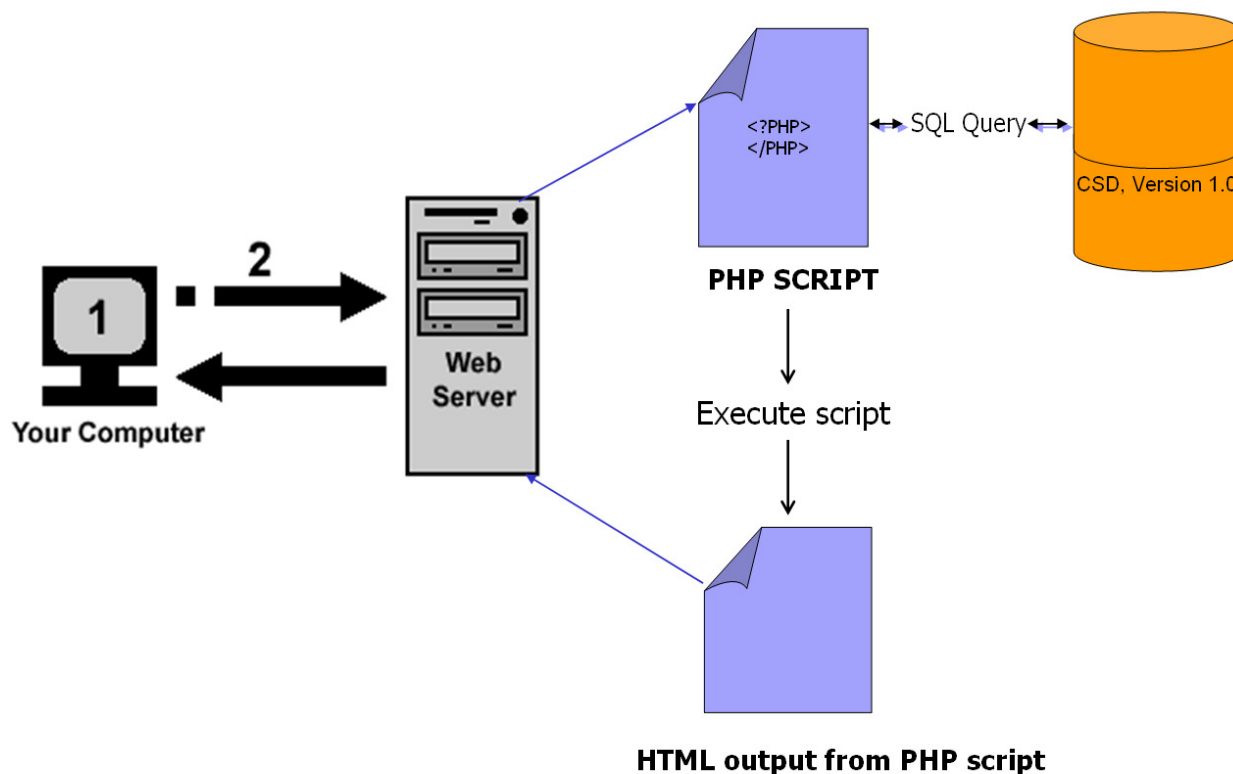
Figure 4. Three tier web architecture of the database.

MetaCyc for detailed view. The fourth and the last class of the database is "literature" which houses the research articles from which the data has been extracted. For more details, each of them is linked to PubMed (Figure 2). The search tool option of the database enables users to have a rapid search of data for a particular bacterial species. CSD also harbors a link to other types of related databases, which will help researchers to collect more information on their subject of interest.

DISCUSSION

This database incorporates most of the current and previously known information about the microbes involved in biological fixation of CO_2. The data included in the knowledgebase are just a small part of information occurring in nature and it is expected to expand further with the pace of scientific research in this area. So, the present version (CSD 1.0), is managing the information about the CO_2 utilizing microbes in an organized and systematic manner that will facilitate the researcher to have an easy access to the relevant information about the concerned microorganisms. The information was managed in a simple and user friendly way which can be retrieved by simple search tool. CSD can help researchers in designing an apposite biological method for CO_2 sequestration.

CSD (Version1.0) is freely accessible at http:// csd.igib.

res.in. and runs on internet explorer 5.5, firefox 1.0, opera 4.0 or any other latest internet browser.

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