BacTech Environmental Corporation

Our Bugs Eat Rocks!

BacTech Environmental Corp, a Canadian cleantech company currently listed on the Canadian National Stock Exchange (CNSX: BAC), has developed and commercialized its proprietary bioleaching technology to remediate historic acid-producing mine tailings.

BacTech's workforce, bacteria that work 24/7 under optimal conditions, are naturally-occurring and harmless to both humans and the environment. There are over 60 strains involved in the oxidation of sulphides, with each strain finely tuned to different sets of conditions. The oxidation process, which naturally takes over 20 years to occur, is achieved within 6 days inside bioreactors, and not only neutralizes the sulphides, but also stabilizes toxic substances, such as arsenic, into environmentally benign compounds that have been approved for safe disposal.

In contrast to conventional smelters that can only treat specific types of material at a time, one single bioleaching plant is able to treat a wide variety of tailings waste from multiple sources, even if their composition is different (i.e. from uranium, gold, copper, zinc and even coal mines).

The cherry on top of the bioleaching sundae is its ability to simultaneously liberate any base and precious metals that are left behind in the tailings from historical mining practices. These metals are then recovered and sold to effectively finance the entire remediation operation *at no cost to the government*. While the focus is currently on abandoned mine sites given their ubiquity, this technology holds great potential for one day *proactively* treating mine tailings as they are being produced so as to prevent the possibility of AMD right from the start!

The Challenge

Mine Tailings & Waste Rock

There is a long and well-documented list of health and environmental hazards associated with these historic mine wastes. The most consistent threats that nearby ecosystems and communities face are Acid Mine Drainage (AMD) and heavy metals contamination.

AMD occurs when sulphides in tailings react with atmospheric conditions to create an acidic solution that, over time, migrates into the surrounding area. In the process, this acidic solution leaches heavy metals into nearby sources of groundwater that eventually make contact with watersheds, soils and vegetation.

The health risks to humans and animals are known now, but this was not the case when historic gold rushes and other mining booms were taking place.

Fast Facts

Abandoned /Orphaned Mines

British Columbia	1,800
Ontario	5,700
Canada	10,000
United States	420,000

BacTech In The News

The Economist - Technology Quarterly
Rocks on the menu
March 12, 2011
Print edition & online

Resource World
BacTech Mining splits in two
February 2011
Print edition

Energy Digital
Mining Safety: Bioleaching Bacteria Clean Toxic Mine Tailings
April 2011
Online edition

Contact

BacTech Environmental Corporation

50 Richmond Street East
Suite 300
Toronto, Ontario M5C 1N7
Canada
Tel: 416-813-0303
info@bactechgreen.com

www.bactechgreen.com

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Acid-producing Mine Wastes

	Tailings		Waste Rock	
	Million Tonnes	Hectares	Million Tonnes	Hectares
Newfoundland & Labrador	29.5	170	0.5	
Nova Scotia	11.3	90	35.9	
New Brunswick	76.5	564	25.7	
Quebec	254.0	2,390	70.0	180
Ontario	984.0	6,481	80.1	
Manitoba	200	1,780	68.8	
Saskatchewan	66.4	273	19.9	
British Columbia	192.0	571	421.0	
Territories	64.0	243	17.0	
Canada	**1,877.7**	**12,562**	**738.9**	**180**

Source: Report of Results of Workshop on Mine Reclamation hosted by IGWG-Industry Task Force on Mine Reclamation (Toronto, Ontario, March 10-11, 1994)

The Advantages of Bioleaching

- Bacteria are naturally occurring, indigenous and harmless to both the environment and human health
- Neutralizing the **source** of acid generation and AMD: sulphides in tailings. Other approaches only address the symptoms.
- Harmful heavy metals, such as arsenic, are converted into stable, environmentally benign products (EPA TCLP II)
- Remediation of tailings with a 'no-cost approach' to governments and communities (e.g., Snow Lake, Manitoba)
- Revenue stream through the recovery of left-over precious and base metals -- Au, Ag, Cu, Ni, Zn, Co, Pb
- Participation of First Nations groups in Northern Ontario with nearby tailings piles
- None of the gaseous emissions that are associated with conventional mineral plants (e.g. $S0_2$,As_20_3)
- Efficient reuse of water from the process
- Able to treat a wide range of tailings from different sources, including refractory, low-grade and non-metal

A New Approach To The Reclamation Of Historic Mine Tailings

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BacTech Environmental Corporation

50 Richmond Street East, Suite 300, Toronto, Ontario M5C 1N7 Canada, Tel: 416.813.0303 Fax: 416.596.9840
www.bactechgreen.com

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Introduction

More than a century of industrial, manufacturing, agricultural and mining processes have left many areas around the world filled with highly-toxic materials and known carcinogens. Until recently, little was done to address the negative environmental consequences of global progress towards an industrial economy. In some regions, no remediation efforts have been taken. Additionally, few governmental regulations have historically existed that require commercial operations, such as mining companies, battery manufacturers and chemical producers, to dispose of toxic waste products properly or to "clean up" after themselves after exiting a geographic area.

In the past, conventional mineral extraction practices in most mining regions involved virtually unregulated processing of the ores, with no disposal control systems for the unwanted rock ("tailings"). Most tailings in the world contain sulphides, other toxic elements, and, where previous mineral extraction technology limitations existed, economically recoverable quantities of precious or base metals.

Sulphides contained in the tailings readily react with the atmosphere to create acid mine drainage ("AMD"). This acidic solution is very effective at liberating certain heavy metals from mine tailings, resulting in pollution of the surrounding watersheds and soils, as illustrated in the picture below.

The issue is so widespread across the globe, and has been going on for so long, that the extent of the contamination is unknown and a complete list of affected sites remains unavailable. Studies of various geographic locations and anecdotal evidence, however, provide a robust understanding of the contamination and public health problem. In the U.S., where some of the most extensive data exist regarding the number of sites affected by toxic materials, the magnitude of the problem is staggering. According to the U.S. Environmental Protection Agency ("EPA"), there are approximately 420,000 abandoned mines, over 13,000 of which are categorized as "abandoned mines with potential environmental hazard," in the states of California, Arizona and Nevada alone.[1] The EPA estimates there are a larger number of hazardous sites in northern Mexico as well. Sites that are deemed "environmentally hazardous" contain metal contaminants like arsenic, lead and cadmium. The National Orphaned/Abandoned Mines Initiative ("NOAMI") of Canada estimates there are 10,000 abandoned mines in the country, the remediation of which will cost several billion dollars.[2]

100 Years of mining in South Dakota, U.S.

The natural oxidation of arsenic-contaminated materials seep along the banks of Whitewood Creek, South Dakota. The water seeping into the stream contains high levels of dissolved iron, arsenic, and manganese.

Photo: US Geological Survey.

A specific example of the toxic impact of unregulated mining can be seen in Thailand. The effect on human health related to arsenic poisoning in a southern province of Thailand was first recorded in 1987.[3] This area, the Nakhon Si Thammarat Province, has a long history of bedrock and alluvial mining, producing significant amounts of waste products such as ores containing arsenopyrite. In 1994, an international group studied the extent of the impact on the surrounding aquifer systems in the area. The team discovered that the local drinking water contained 500 times the World Health Organization's potable drinking guidelines for dissolved arsenic. One thousand people were treated for skin problems by the late 1990's.[4]

[1] Superfund Basic Research Program, University of Arizona. Mine Tailings. Accessed 20 May 2009. <http://superfund.pharmacy.arizona.edu/Mine_Tailings.php>

[2] The National Orphaned/Abandoned Mines Initiative, Action Plan 2006 Status Report (British Columbia: 2007) 17.

[3] Selinus, Olle. Essentials of medical geology: impacts of the natural environment on public health. Published by Academic Press, 2005, p. 283.

[4] Ibid

These are examples of the worldwide mining-related arsenic issue. Arsenic contamination, however, is a significant problem in many parts of the world. Arsenic leaching from mine tailings in the U.S., Canada, Australia, Japan, Mexico, Thailand, United Kingdom, Argentina, Cambodia, China, Ghana, Hungary, Mexico, New Zealand, Philippines and Taiwan, have been documented. Other major sources of arsenic around the world have been synthetic pesticides and naturally occurring, though still toxic, forms in alluvial plains in various regions.

Arsenic has been linked to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate, while non-cancerous effects include thickening and discoloration of the skin, stomach pain, nausea, vomiting, diarrhea, numbness in hands and feet, partial paralysis and blindness.

Various Areas Around the World Heavily Contaminated by Mining-Related Arsenic

BacTech Environmental

BacTech Environmental Corporation ("BacTech") is a newly-formed, publicly-traded Canadian company based in Toronto, Ontario, and trading on the Canadian National Stock Exchange (CNSX) under the symbol BAC. The Company was launched on December 2, 2010 upon completion of a Plan of Arrangement initiated by BacTech Mining Corporation. Under the Plan, BacTech Mining Corporation ("BMC") was re-named REBgold Corporation and that company will continue to pursue primary mining projects. BacTech Environmental Corporation was created as in independent company to pursue the environmental remediation of historic mine tailings and waste rock. On completion of the Plan of Arrangement, holders of BacTech Mining Corporation shares were issued one new share of REBgold for each BMC share held, and 1/5 of a share in BacTech Environmental.

To enable the new company to conduct its business, BacTech was granted an exclusive, perpetual license to use REBgold's bioleaching technology for the remediation of historic mine tailings and waste rock. To avoid confusion, we will refer to BacTech as being the owner of the technology as it pertains to environmental remediation projects.

REBgold has developed a biological reactor leaching process – BACOX – that can also be applied to the remediation of tailings in an economically beneficial manner. Bioleaching is a commercially-proven process and has over 20 applications on a global basis. All projects have focused on the stabilization of arsenic, in addition to the liberation of the contained gold. BacTech's business plan is to apply this commercially-proven technology to arsenic remediation and recovery of contained metals.


Bioleach tanks

REBgold's bioleaching technology employs the use of naturally-occurring bacteria, harmless to both humans and the environment, to liberate precious and base metals from difficult to treat ores, concentrates and tailings produced by the mining industry. REBgold is one of only two companies to have successfully commercialized gold bioleach technology. By virtue of having no direct competition, the company is the leader in the base metal bioleach arena as well.

REBgold successfully designed, engineered, licensed and built bioleach plants for clients in the gold industry and has over 20 years of experience in the field of bacterial oxidation or "bioleaching". However, no such plants exist in the base metal industry. BacTech Environmental is now poised to transfer this technology to environmental remediation applications that offer favourable economics through metal recovery.

Arsenic Stabilization

An important feature of the bioleach processing strategy is that over 90% of the associated arsenic is collected into a small concentrated mass of approximately 7% of the original tails volume before bioleaching treatment is applied. This results in the tailings material being stripped of significant amounts of arsenic very early in the process and, effectively, 93% of the tailings are deposited back on site without any harm to the environment. The small remaining mass of concentrate (7%) containing the arsenic and other metals is then fed into bioreactors with appropriate reagents, whereby bacterial metabolism liberates arsenic and the other base metals into an acidic and oxidized solution.

It is a continuous process and, after only five to six days residence time in the tanks, a benign gold or silver solid is removed for sale to market, with the solution treated with limestone to precipitate ferric arsenate which can then be sent to a landfill site. The remaining liquor undergoes a lime treatment to precipitate out base metals which will be sold to a conventional metal processor.

Global Market

There is a very large emerging market for bioleach technology. In the states of California, Arizona and Nevada alone, there are approximately 420,000 abandoned mines, with over 13,000 categorized as "abandoned mines with potential environmental hazard." In Canada, NOAMI estimates there are 10,000 abandoned mines. Arsenic leaching from mine tailings in Australia, Japan, Mexico, Thailand, United Kingdom, Argentina, Cambodia, China, Ghana, Hungary, Mexico, New Zealand, Philippines and Taiwan, has also been documented.

These kinds of old mines have two things in common. First, the ore that has been left behind oxidizes over time and provides a continual stream of acid mine drainage into local streams, lakes and rivers, accompanied by other soluble elements such as arsenic, bismuth, antimony and other base metals. This has a serious impact on the health of local residents living downstream from tailings. In addition, the soils usually used for agriculture also see higher levels of contaminants, resulting in seriously diminished or unusable soil. Second, the process technology employed by the historic miner was inefficient, resulting in tailings with residual metal grades that are currently economically feasible to recover, if done in an environmentally responsible manner.

While we believe that a large target market exists, for the sake of simplicity, in this document we focus on the closest geographic opportunities. Our current marketing approach and business model should allow for the commissioning of two bioleaching facilities in Ontario, two in Quebec, and one in Manitoba. It is important to state that in all these situations, we would be looking to partner any plant with a mining or reclamation company with experience in material moving and concentration production. Not only does this allow us to partner with companies with local expertise, it also allows us to focus on what we do best, which is building and operating bioleach facilities.

BacTech's goals include exporting BACOX technology across Canada and to other countries where environmental relief from past mining practices is needed. BacTech has identified 5 immediate opportunities in northern Ontario, 2 projects in Mexico, the Snow Lake area of northern Manitoba and the Mother Lode district of California. The U.S. government's stimulus package earmarked $1.5 billion for mine reclamation and we intend to vigorously pursue projects in the U.S. that would be amenable to bioleaching.

Market Forces and Barriers

There is very little competition with our technology in the market place. Currently, there is only one other successful commercial bioleaching company for gold, and none for base metals, or for the removal of toxic heavy metals. The successful outcome of the Manitoba tailings project will allow BacTech to gain a first mover advantage throughout Canada and internationally.

Competition with our technology comes from alternative, historical approaches. The most prevalent method to treat sulphide ores has been pyrometallurgy, which involves roasting or smelting. Smelters and roasters are the most effective from a recovery standpoint, however, they suffer from the creation of SO_2 and As_2O_3 emissions. They are also extremely costly from a capital standpoint, with new facilities costing well over $1 billion for smelters, and new construction generally faces intense opposition from municipalities (i.e., NIMBY syndrome). It would be difficult to economically justify a tailings reclamation and remediation project using this expensive approach.

Pressure oxidation is a hydrometallurgical process that has been used in the past, primarily for treating copper sulphides. It is also a capital intensive technique due to the need for an oxygen plant and constant, expensive maintenance. It is a cleaner technique than pyrometallurgy, however, the capital cost is generally twice that of bioleaching. The plants are also more complicated to operate, and it requires much more material processing than most tailings projects can provide.

The table below summarizes the benefits of bioleaching and the negative impacts associated with alternative methods of remediation or metal recovery.

Summary Comparison
BacTech Bioleaching Technology vs Alternative Methods of Refraction and Remediation

Technology	Discussion	Metal Yields	Environmental Impact(s)/ Costs
Tailings Remediation			
BacTech Bioleaching Technology	Harmless bacteria used in controlled process. Creates non-hazardous waste and release of precious and base metals which are sold.	Produces precious and semi-precious metals to sell. >95% yield.	Non-hazardous waste, eliminates toxins permanently
Historical Efforts	Dump tailing materials in area body of water or leave at site	NA	No effort to prevent AMD
Physical Stabilization	Cover the area with non-hazardous materials or cement over. Cost estimated at $1.50 - $4.50 per m3 for mine tailing remediation.[5]	NA	Limited success and high cost
Chemical Stabilization	Combine the tailings with certain chemical substances to contain	NA	Limited success and high cost
Frozen Block Method	Involves freezing the arsenic trioxide chambers and stopes, and the rock surrounding them. Provide an impenetrable barrier so that water cannot get in and arsenic-contaminated water cannot get out. Super-cooled liquid will be circulated through a series of underground pipes.	NA	Hazardous waste is frozen underground indefinitely and high cost. Limited success
Phytoremediation	Using certain plants to soak up toxic elements, such as arsenic and cadmium, over time	NA	Limited long-term experience
Refractory Methods			
Roasting/Smelting	Burn the materials in a kiln at extremely high temperatures, depending on the materials, to convert the sulphide values to sulphur gas and separate minerals	98%	Releases sulphuric gasses into atmosphere
Autoclaving/Pressure Oxidation	Technology not capable of releasing sulphide-intensive materials. Need high grade of gold in ore. Very high capital costs.	98%	
Bateman's BIOX Group – Bioleach-based Gold Mining	Formerly Gold Fields Mining's technology. Focused on gold mining only.	>95%	

[5] Berti WWR , Cunningham SD. 2000. Phytostabilization of metals. In: Phytoremediation of Toxic Metals–Using Plants to Clean Up the Environment (Raskin I, Ensley BD, eds). New York: John Wiley & Sons, 71–88.

The value of our product is dependent on the underlying commodity price. Commodity prices have strengthened during the first half of this year and are expected to remain strong over the next few years. It is difficult to predict the future, but upon completion of our Snow Lake plan, we should be in an expansionary economic environment which could lead to more robust base metal prices. Furthermore, it is to our advantage that we are starting with a feed material that has already been mined/milled, which decreases much of the cost of metal production in comparison to other mining operations.

Currently, the most difficult market access issue is access to capital, given the state of the equity markets for junior companies. Bankers have curtailed their lending and are drastically reducing their exposure to risky projects. We are assisted by the fact that REBgold has constructed and operated three gold plants with a different form of the technology. Of late, we are seeing an increasing interest from “cleantech” financial sources. We intend to expose our company and process through participation in conferences such as the CleanTech Forums.

To date, we have received very favourable responses from governments as our technology offers a safe and clean method for removing a longstanding environmental contaminant without a cost to the taxpayer. Historically, there has been some resistance in the mining community towards the effectiveness of reclaiming the tailings but, again, this simply underlines the necessity of a plant to demonstrate the economic and environmental capabilities of our technology. Ironically, this resistance is often created because of a poor understanding by mining operators who cannot gain ready access to the technology in the open market due to intellectual property protection and know-how by REBgold and Gold Fields.

Marketing Plan

We believe that the successful operation of the Snow Lake plant (see “Project – Snow Lake, Manitoba” below) will be the most effective form of marketing at our disposal. The mining industry is a relatively small community, even though the industry operates worldwide. Most head offices can be found in a handful of cities such as Toronto, Vancouver, Denver, London and Sydney. Given the fact that our business strategy is based on joint ventures with mining companies and governments, we can easily identify our potential partners by locating the existing tailings opportunities. We believe word of our results to date have spread very quickly through the sector.

The Internet is also a valuable tool for sourcing these opportunities. In fact, the Snow Lake project was found through a search on Google for “arsenic tailings”. Usually, we can make a determination from the available data whether to pursue an opportunity. This saves time and allows us to narrow the focus of our search. We have found that most mining companies prefer to understate any potential environmental issues they have. We believe this is directly attributable to postponing the inevitable costly closure until such time as they are mandated to do so. What we offer is a low cost, possibly cash positive, approach to tailings remediation.

Finally, we will attend as many Cleantech conferences as possible in the next 12-18 months. The Cleantech organization has done a very effective job of assembling most of the prominent financial pools of capital from the sustainable development space at conferences in North America, Europe, Australia and China.

Risk Mitigation

Comprehensive metallurgical test work on tailings material is the main method of mitigating technical risk on a project, supported by process modeling and predictive analysis for “what-if” scenarios. Test work and modeling exercises provide input to achieve the most effective plant design for maximizing the arsenic reclamation and stabilization per unit cost and obtaining metal products meeting end-user specifications.

Engaging professional engineers, recognized and well qualified, with a demonstrated track record in this type of project, will also mitigate the technical project risk. Planning and site-work must begin early in a

project time scale, as permitting times can be lengthy, and an early start will mitigate the risk of non receipt of approvals before procuring capital equipment. Any early procurement activity is also scheduled for long lead items in order to mitigate the possibility of delays in construction due to the late delivery of equipment. Contact with potential end-users of the final metal product is also essential as an early activity to ensure that product specifications are readily achievable.

Commercial Plant Roll Out

An approximate value for the target market in the next five years is calculated using a 1,000,000 tonne of tailings per annum bioleach facility beginning in 2013, with one plant per year coming on-line over the next five years. Although the capital requirements for each plant may vary according to quantity of metals, arsenic and sulphides present, for the sake of simplicity in this exercise, it is assumed that each plant will have an average capital expenditure of $50 to $70 million. In a similar manner, the operating expenditure of each plant and revenues will also vary, but a treatment cost in the order of $27.00 per tonne and a conservative value per tonne from concentrate sales of $90 is assumed here (refer to table below). A great deal of upside exists with increased throughput, production of LME grade metal on site, and increased commodity prices.

The chart below does not incorporate the Manitoba Snow Lake project, as we are dealing with concentrates at that location and not tailings. Therefore, the CAPEX for Snow Lake is significantly reduced.

Year	TPA (000's)	CAPEX (000's)	OPEX $/tonne	Revenue $/tonne	EBITDA (000's)
2013	1,000,000	70,000	27.00	90.00	27,000
2014	2,000,000	70,000	27.00	97.00	60,000
2015	3,000,000	70,000	27.00	104.00	103,000
2016	4,000,000	70,000	27.00	108.00	145,000
2017	5,000,000	70,000	27.00	110.00	188,000
2018	5,000,000	70,000	27.00	113.00	194,000

In terms of present day dollars over a 10 year period, using an 8% discount rate, the net present value ("NPV") is $920 million; using a 10% discount rate, the NPV is $820 million.

Project – Snow Lake, Manitoba

In April 2011, BacTech was granted a contract by the government of Manitoba to reclaim a stockpile of arsenopyrite gold concentrate that sits on surface beside the Snow Lake Mine in northern Manitoba. The concentrate was produced as a by-product of the gold mine at the then-named New Britannia Mine. Given the arsenic nature of the concentrate, the mine owners floated the concentrate and "stored" it on the ground to be dealt with at a later date. Fifty years later, the concentrate, which is leaking arsenic into the surrounding area, has become the responsibility of the Manitoba government.

Based on historic data provided by the Manitoba Mines Branch in their Request for Proposal, the stockpile is estimated at approximately 250,000 tonnes, with an average grade of approximately 9 grams of gold per tonne. BacTech secured the contract by offering a "no cost to the taxpayer" solution to the government. In essence, BacTech will take on the reclamation project at no cost to the government, but will retain any metal recovered from the stockpile for our own account.

The Company plans to build a $20 million plant capable of treating and stabilizing the arsenic, with the liberated gold flowing to BacTech as compensation. Onsite work begins in May 2011, with initial bioleach results expected by the Fall of the same year. Successful test work using bioleaching would see the construction of a bioleach plant begin by summer 2012, with a full operating plant in place by the 4th quarter of 2012.

Success for BacTech will also place a Canadian company as an international leader in economically positive reclamation, and provide us with a first mover advantage. Further, marketing, technical training for BacTech plant operators, and local involvement will be generated by the creation of a centre for bioleaching excellence at the College of the North in Flin Flon, Manitoba, also producing many jobs and opportunities. As a result of releasing news on the Snow Lake project, we are fielding numerous enquiries from groups in Russia, Armenia, Canada and the United States with respect to our technology being used for mine tailings.

Dr. Paul Miller is leading BacTech's technology development. Dr. Miller has 30 years of experience in bioleaching and was responsible for five bioleaching projects, including the Youanmi mine in Western Australia, Beaconsfield in Tasmania, Laizhou in Shandong Province, China, Peñoles in Mexico, and the BioGold expansion in China. In addition, BacTech was fortunate to recruit Dr. Junxiang Guo, a metallurgist with considerable expertise gained from 6 years employment at the bioleach plant REBgold built in China.

Personnel

One challenge we foresee, is obtaining a suitable supply of bioleach technicians capable of assisting in rolling out the technology to new projects. We envisage that a commercial facility may create over 30 full time jobs and, with this in mind, we intend to offer courses in bioleaching at the College of the North in Flin Flon, Manitoba, perhaps as early as September 2011. Drs. Miller and Guo will work with the institution to establish a course based on the BacTech training manual that has been used in past projects. This will complement their existing courses in conventional mining and mineral processing. Once the physical construction of the plant has been completed, we will need a number of technical people, from managers to operators and fitters, to oversee the operation of the bioleach plant.

Depending on the availability of skilled technicians, we have the capacity to build up to 3 plants on an annual basis. This would include the expansion of existing operations that are looking for increased throughput. At this time, bioleaching is the only process technology that can be built relatively inexpensively and modularly to take advantage of tailings opportunities. The capital required for roasting or pressure oxidation prohibits their involvement in most projects that BacTech would evaluate.

Contact Information

M. Ross Orr, President & CEO
BacTech Environmental Corporation
50 Richmond Street East, Suite 300
Toronto, Ontario M5C 1N7
Telephone: 416-813-0303 ext 222
Email: info@bactechgreen.com
www.bactechgreen.com